A SHORTCOURSE BOOK

THE TEXTBOOK OF DIGITAL PHOTOGRAPHY

This text introduces you to the entire field of digital photography from buying a camera to hanging your photos in a gallery or posting them on a Web site. There has never been a more exciting time to be learning about photography, or a more interesting book to learn from!

DENNIS P. CURTIN

HTTP://WWW.SHORTCOURSES.COM
HTTP://WWW.PHOTOCOURSE.COM

Short Courses Publishing Program

Short Courses, the parent site of PhotoCourse.com, is the leading publisher of digital photography books, textbooks, and guides to specific cameras. Be sure to visit the Short Courses bookstore at http://www.shortcourses.com/bookstore/book.htm. One of our specialities is high-quality camera guides so be sure to visit the store to see if there is a book on your camera. If you find any errors in this book, would like to make suggestions for improvements, or just want to let me know what you think—I welcome your feedback, even though I can't always respond personally.

CONTACT/FEEDBACK INFORMATION

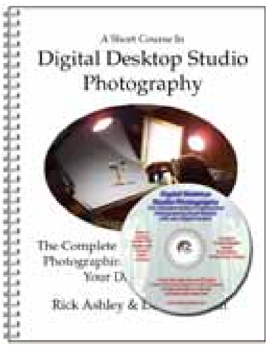
ShortCourses.com
16 Preston Beach Road
Marblehead, Massachusetts 01945
E-mail: denny@shortcourses.com
Web site: http://www.shortcourses.com

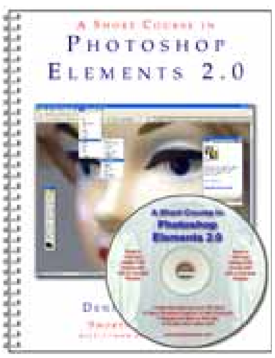
COPYRIGHT NOTICE

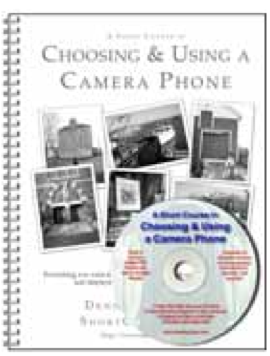
WEB SITES

To learn more about digital photography visit our two Web sites:

- http://www.photocourse.com
- http://www.shortcourses.com







Other books in which you may be interested.

SHORT COURSE BOOKS

Short Courses on Canon Camera Photography

■ Pro 1 ■ EOS Digital Rebel/300D ■ EOS 10D ■ G5 ■ G3 ■ EOS D60 ■ EOS D30 ■ G2 ■ G1 ■ S300 ■ S110 ■ S100 ■ S20 ■ A5/A50 Zoom

Short Courses on Nikon Camera Photography

■ D70 ■ D100 ■ 4500 ■ 5700 ■ 5000 ■ 995 ■ 990 ■ 950 ■ 880

Short Courses on Olympus Camera Photography

■ C-5050 ■ C-4040 ■ C-700 Ultra Zoom ■ E-20 ■ E-10 ■ C-2100 Ultra Zoom ■ C-3040 Zoom ■ C-3030 Zoom ■ C-2500L ■ C-2040 Zoom ■ C-2020 Zoom ■ C-2000 Zoom

Short Courses on Sony Camera Photography

■ DSC-F828 ■ DSC-F717 ■ DSC-F707

Textbooks & General

■ Choosing and Using a Camera Phone ■ Displaying & Sharing Your Digital Photos ■ Photoshop Elements 2.0 ■ The Textbook of Digital Photography ■ Digital Desktop Studio Photography ■ Managing Digital Pictures with Windows XP and Beyond ■ Choosing and Using a Digital Camera ■ Using Your Digital Camera ■ The Digital Photographer's Ultimate Software Collection

ISBN: 1-928873-43-X

Using this Text in the Classroom

If you are using this text in a class, you must have a personal copy of this CD that contains the text in PDF format and also acts as your license agreement. If you do not have such a CD, you may be using an illegal copy. To see how to qualify for classroom copies or to determine if you are using a legal copy, visit our site at www.photocourse.com.

The *Textbook in Digital Photography Project* was established by ShortCourses.com to develop and distribute high-quality yet afford able materials in digital photography for both classroom and independent study. With photography texts from traditional publishers reaching $80, it was time to try a new approach more attuned to the digital era—full-color, fully searchable PDF eTexts that can be displayed on any computer using Adobe's free Acrobat reader. eTexts and PDF files are revolutionizing the publishing and printing businesses in many ways including the following:

- *Timeliness*. Since large quantities of inventory aren't required, we can revise and update materials as needed instead of on a fixed schedule every 2 or 3 years. In a rapidly evolving field such as digital photography these frequent revisions are often required to keep materials up to date.

- *Distribute and print*. Textbook publishers work on a *print and distribute* basis. This means they take enormous risks, tie up lots of capital, and bear marketing, sales, warehouse, shipping, and billing costs. All of these costs are passed on to you, or more accurately, your students or their parents. The emerging model, used by this eText, is called *distribute and print*. Using this model, materials are distributed around the world electronically and then printed where needed.

- *Print on demand*. Textbook publishers print in large runs, increasing their risks and prices. The *print on demand* model is to print only when a copy is ordered, eliminating warehousing expenses. This same model applies to using this eText. You only print selected pages or chapters when they are needed. You no longer have to carry a backpack full of books, and if you loose your materials, you just print another copy.

This text is part of a larger package that introduces you to all aspects of the rapidly emerging world of digital photography. The package consists of the following elements:

- *The core text* (this book), introduces the entire panorama of digital photography and includes the following topics:
  - Introduction to the digital camera and digital images (Chapter 1)
  - Introduction to the digital darkroom (Chapter 2)
  - Camera controls and creative photography (Chapters 3–6)
  - Flash and studio lighting (Chapter 7-8)
  - Sharing and displaying digital images (Chapter 9–10)
  - Exploring beyond the standard still image (Chapter 11)
  - Understanding pixels and image sizes (Chapter 12)
  - Caring for your camera, scanning, shooting RAW images (Appendix)

- *Lab manuals* on photo-editing present Photoshop Elements and eventually Photoshop CS. These comprehensive, yet easy to follow guides are published separately because photo-editing normally runs in parallel with the materials discussed in this core text.

- *Supplements* are published periodically between editions to keep this text more timely.

Be sure to frequently visit the project's Web site (www.photocourse.com) for an up-to-date listing of what's available. For additional information on digital photography, visit the publisher's Web site at www.shortcourses.com.

SCHOOL DISCOUNTS

Special discounts are offered on copies shipped to school addresses. For information e-mail Peggy at *peggy@shortcourses.com*.

Preface

Not long ago the course title "*Digital Photography*" implied a course on Photoshop. As digital cameras have become increasingly popular, the introductory course has also gone digital so you are now introduced to photography using a digital camera. As this new era of digital photography matures, it won't be long before the "*digital*" in "*digital photography*" is no longer needed. It will be assumed, because that is the way almost all photography will be done. One of the primary reasons for this rapid movement from film to digital imaging is that photos are embedded in a world that has gone digital. To take full advantage of the digital world in which we live, photographs also need to be digital. For awhile, capturing images on film and then scanning them into a digital format was a solution. However, this process is expensive and time consuming. Digital cameras remove those impediments and capture images that are already in a universally recognizable digital format that makes them easy to display and share. You can insert digital photographs into word processing documents or PowerPoint presentations, print them on almost any material, send them by e-mail, integrate them into slide shows to be played on the TV, post them on a Web site where anyone in the world can see them—even have them laser-etched into glass or granite. A digital camera, a computer, and a high-speed Internet connection make each of us a member of an ever-expanding network or community of photographers and viewers.

Just as digital images make it easy to integrate photos into many of the other things we do, digital technology makes it easy to add cameras to other devices. One of the current trends is to embed cameras into cell phones, personal digital assistants, and other mobile devices. With just a push of a few buttons, you can snap a picture and immediately e-mail it or post it on a Web site. It won't be long before there are digital cameras everywhere, all the time. What impact this will have on our photography remains to be seen, but if history is any indicator, people will soon be discovering practical, creative, and even artistic ways to use these new tools.

Changes in technology always open new opportunities and present approaches that change the way images look and are used. For example, the introduction of the 35mm Leica in the 1930s made it easier to capture fast-moving action. Images became more spontaneous and fluid, a far cry from the more formally posed images required by much larger and more awkward cameras. Smaller cameras allowed photographers to discretely capture life on the street and people in motion, without modifying the flow of action by his or her simple presence. With cameras being built into more and more cell phones and portable digital assistants, an even larger impact is possible.

Although it's both the immediacy and flexibility of digital photography that has made it so popular, there is one aspect that is rarely mentioned. This is the new freedom it gives you to explore creative photography. In the 1870's when William Henry Jackson was carrying 20 x 24 glass plate negatives around the West on a mule, you can bet he hesitated before he took a photograph. We may not be carrying window-sized glass plates, but you and I also hesitate before taking a picture. We're always doing a mental calculation "is it worth it?" Subconsciously we're running down a checklist of costs, times, effort, and so on. During that "decisive moment," the image is often lost or we fail to try new things. We lose the opportunity for creative growth and choose to stay with the familiar that has delivered for us in the past. Surprisingly, Jackson had one big advantage we've lost over the last

TRY THIS WITH FILM!

- In the summer of 2003, the Associated Press reported that a 15-year-old boy had foiled an abduction by using his camera phone to take photos of the man and his car's license number. The man was arrested the next day.
- A man stranded on an ice floe during a solo trek to the North Pole took a digital photo of the 1,000 foot runway he'd dug by hand and e-mailed it to air rescue showing them that a landing was possible.

Signs offering film developing are rapidly changing to signs offering to make prints from your digital files. "From today, painting is dead!" exclaimed painter Paul Delaroche when he saw the first daguerreotype in 1839. He was wrong, but can we revise the sentence to "From today, or someday not too far off, film is dead!"

The Leica changed the way photographs were captured.

century. If an image didn't turn out, or if he was out of glass plates, he could just scrape the emulsion off a previously exposed negative, recoat the plate, and try again. Digital photography not only eliminates that nagging "is it worth it?" question, it also returns us to that era of endlessly reusable film (and we don't need a mule to carry it). Hand the camera to the kids, take weird and unusual angles, shoot without looking through the viewfinder, and ignore all previously held conceptions about how to take photographs. You may be surprised at the photos you get if you exploit this new era of uninhibited shooting.

> *The virtue of the camera is not the power it has to transform the photographer into an artist, but the impulse it gives him to keep on looking—and looking.*
>
> Brooks Atkinson
> *Once Around the Sun*

Digital cameras are only a few years old, and we are only at the dawn of this new era. Where it will lead no one really knows, but it's exciting to play a part in this dramatically changing world. As you begin to explore the field, you will be awash in technical jargon. Most of it can be safely ignored. To show how some things never change, here is what Jacob Deschin, the photographic editor of the New York Times, wrote in 1952 about the earlier era when the Leica revolutionized photography:

"When 35mm was in full flower in this country–in the miniature's golden Thirties–photographers in the new medium became "experts" overnight, full of tall talk about small grain and big enlargements. They had to, in self defence, for in those early days of the miniature it seemed important to be technically hep, at least in conversation. Never mind the pictures! In spite of much hokum, much good came to the surface, survived the babel and exerted an influence that has since benefitted all photography."

A mule carries William Henry Jackson's photographic outfit. Courtesy of the Library of Congress.

Contents

Chapter 1
Digital Images & Digital Cameras

CONTENTS

Digital images are formed from tiny dots of red, green and blue color. The dots, usually many millions per image, blend into the smooth continuous tones we're so familiar with from film. These images are captured directly with digital cameras, or by scanning a transparency, negative, or print. The end result is an image in a universal format that can be easily manipulated, distributed, and used. This digital format for images, and the development of the Internet in particular, have opened exciting new vistas for photography which we'll explore in this text. To begin, we first look at digital cameras and digital images. This chapter lays the foundation for your understanding of digital imaging.

Digital Photography—The Past and the Future

The small image is typical of photos captured by the first digital cameras. The larger image is typical of those captured by more recent models.

It was only a few short years ago, around 1995, when digital photography appeared on the scene for most of us. In that year, Apple's QuickTake 100 and Kodak's DC40 both broke the $1000 barrier for digital cameras. These filmless cameras captured very small images, but they were immediate hits. Small businesses, realtors, insurance agents, and other early adopters snapped them up. They were so popular that the early models were soon followed by a steady stream of digital cameras from Casio, Sony, Olympus and others. The race was on and the stream of new cameras not only continues, it accelerates. Things have advanced so far that the same money that would have bought one of those early cameras will now buy one that captures images 20 times larger and has many more features such as video, sound, and professional style controls.

The Canon EOS DCS 3 digital camera was introduced in July 1995 and captured images containing 1.3 million pixels. It cost about $17,000.

These cameras weren't developed in isolation. Professional cameras, based on film cameras but with image sensors added to capture digital images, were growing in popularity among professionals. However, their high prices, often $20,000 or more, made these cameras available only to an elite few. Kodak had also already introduced the Photo CD process where they inexpensively scanned slides and negatives into a digital format. The process caught on with professionals, but not with amateurs as Kodak had hoped. Meanwhile, publishing, advertising, medicine, and many other fields were going digital. Digital images slipped easily into this trend because they could be instantly displayed, e-mailed, and inserted into documents. It was professionals who led the change from film to digital, but it wasn't long before many more of us were headed in the same direction. Film is no longer just a mature industry, it's dying. Given the scale of this change, how did it all come to pass?

If there were ever two inventors who haven't gotten the public credit they deserve, it's George Smith and Willard Boyle who invented the charge-coupled device (CCD) at Bell Labs. At the time they were attempting to create a new kind of semiconductor memory for computers. A secondary consideration was the need to develop solid-state cameras for use in video telephone

The Canon PowerShot 600 digital camera was introduced in July 1996 and captured images containing 500 thousand pixels. It was priced just over $1000.

Willard Boyle (left) and George Smith (right). Courtesy of Lucent Technologies.

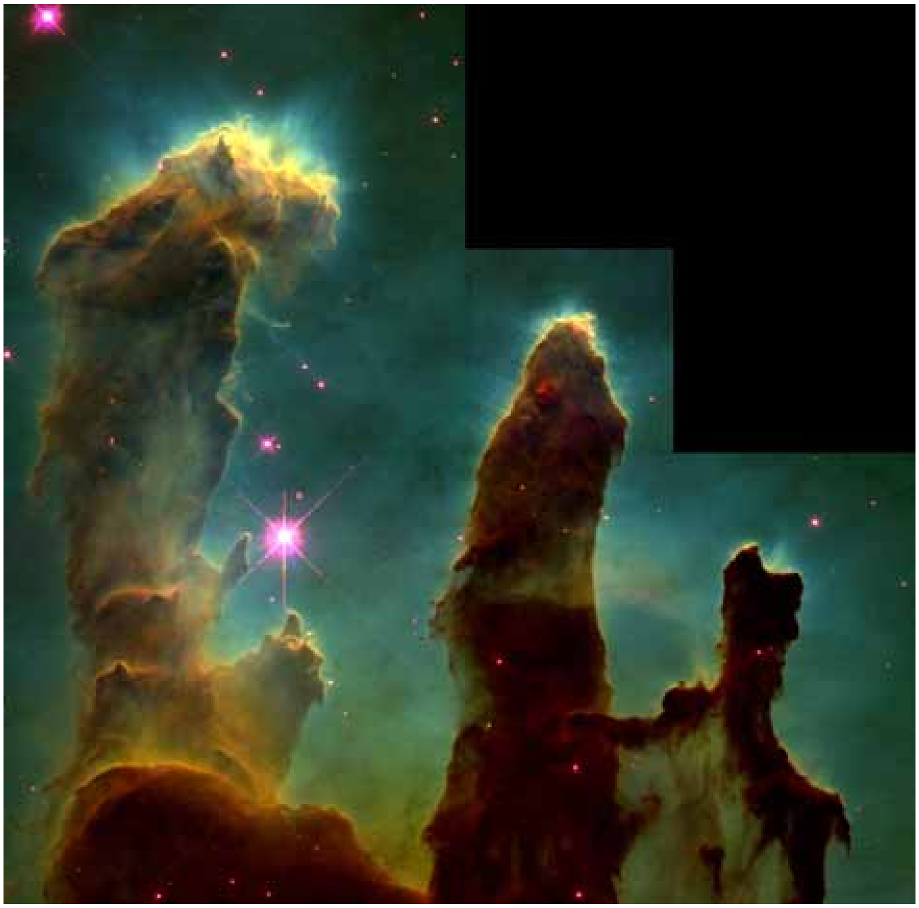
service. In the space of an hour on October 17, 1969, they sketched out the CCD's basic structure, defined its principles of operation, and outlined applications including imaging as well as memory.

By 1970, the Bell Labs researchers had incorporated the CCD into the world's first solid-state video camera. In 1975, they demonstrated the first CCD camera with image quality sharp enough for broadcast television. CCDs then quickly went on to revolutionize the fax, scanner, copier, bar code, and medical photography fields.

One of the more exciting, and demanding applications has been in astronomy. Since 1983, when telescopes were first outfitted with solid-state cameras, CCDs have enabled astronomers to study objects thousands of times fainter than what the most sensitive photographic plates can capture, and to capture in seconds images that would have taken hours before. Today all optical observatories, including the Hubble Space Telescope, rely on digital information systems built around mosaics of ultrasensitive CCD chips. Researchers in other fields have put CCDs to work in applications as diverse as observing chemical reactions in the lab and studying the feeble light emitted by hot water gushing out of vents in the ocean floor. CCD cameras also are used in satellite observation of the earth for environmental monitoring, surveying, and surveillance.

With digital cameras now embedded in phones, personal digital assistants, toys, and other devices, there is no telling where we are heading. All we can say for sure is that things will continue to change rapidly and it will be exciting to follow and take part in this photographic revolution.

With cameras now being added to cell phones, you can click photos and send them to a friend or post them on a Web site. Image courtesy of Sony-Ericsson.



Digital photography started in astronomy and still serves that field well. Here is an amazing photo of gas pillars in the Eagle Nebula. The tallest pillar (left) is about 4 light-years long from base to tip. Forming inside are embryonic stars. Credit: Jeff Hester and Paul Scowen (Arizona State University), and NASA (http://hubblesite.org).

CREDIT

The material in this section about Willard Boyle and George Smith is adapted from material written by Patrick Regan of Bell Labs Media Relations.

Types of Digital Cameras

A digital camera is embedded in a disposable capsule that is swallowed by the patient. As the capsule passes through the GI tract, it transmits video signals which are stored in the receiving unit. These signals also enable the system to trace the physical course of the capsule's progress. Courtesy of Given Imaging.

Digital cameras come in all shapes and sizes and no one yet knows what a digital camera should look like. 35mm cameras have taken familiar forms because form follows function and they require room for the film and light path as well as prisms and such. Digital cameras are freed of many of these limitations so they can take new forms. During these early days, some companies make their cameras look like familiar 35mm cameras while others veer off in new directions. Increasingly cameras are even built into other devices such as cell phones and digital camcorders.

Regardless of how digital cameras look, the market for them is roughly divided into categories with blurry lines separating cameras based mainly by image size, features, and of course, price.

POINT AND SHOOT CAMERAS

For the past few decades, serious photographers have mainly been using traditional 35mm SLR cameras. But these large and heavy cameras are inconvenient to say the least, so most serious photographers have always stuck a point and shoot camera in their shirt pocket. The photos from these small cameras may not be quite as good (and that is debatable), but they go anywhere, and pictures that would otherwise be missed are captured. These cameras are fully automatic and usually don't provide you with every possible creative control—that's why they are called "point and shoot." Point and shoot cameras have earned their stripes and are welcome additions to even the most professional photographer's camera collection. Increasingly, point and shoot cameras are being embedded in mobile devices such as camera phone, smart phones and personal digital assistants (PDAs). These embedded cameras, once almost toy-like, are rapidly moving up the quality ladder with 3 megapixel sizes available in some parts of the world.

Digital point and shoot cameras are fully automatic and usually small and easy to carry. Courtesy of Sony (top and bottom) and Canon (right).

ADVANCED AMATEUR CAMERAS

Positioned just above the point and shoot cameras is a family of cameras with larger image sizes and more advanced features. These cameras appeal to serious photographers who like to have more creative control of their camera's settings and make larger prints. Because their features appeal to both experienced amateurs and professionals, they are sometimes called *prosumer cameras*. With these cameras you have as much, or more, creative control as you do with 35mm SLR cameras.

High-end amateur cameras have both automatic and manual exposure modes plus many other features. Courtesy of Canon.

Advanced amateur and professional cameras are often designed to work with traditional 35mm SLR lenses and other accessories. Courtesy of Canon.

PROFESSIONAL CAMERAS

At the highest end of the spectrum are the professional digital cameras including digital versions of professional 35mm SLR film cameras. One huge advantage these cameras have is that they accept most of the accessories such as lenses and flash units designed for the film versions. They also work much the same way as the film version, so if you are familiar with that version there is less to learn.

Digital backs are designed to be used with traditional large format cameras in place of film. Courtesy of BetterLight.

Large format cameras used by most studio and a few nature photographers have also gone digital. In most cases you can switch between digital and film just by switching the camera's back. A digital back can replace the film magazine on a medium format camera and slide into the back of a 4 x 5 or larger camera just like a film holder. These digital backs come in two basic forms: linear and area arrays.

- *Linear array backs* scan the image much like a scanner scans a page. The image gets built up one line at a time. The time it takes to scan an image makes these backs suitable only for static subjects under continuous illumination. Scan backs usually use three strips of CCDs (called a *trilinear array*) so it can capture a full color image in one scan.
- *Area arrays* are like the CCDs in consumer digital cameras and capture full color images instantaneously. A few use three separate image sensors, each with its own colored filter so it captures just red, green, or blue light.

Choosing a Digital Camera

Casio makes cameras no larger than a credit card and not much thicker. Courtesy of Casio.

As you might expect, Sony explores new directions with some of their digital cameras. Courtesy of Sony

Swiveling and tilting monitor.

Cameras are now being built into personal digital assistants and smartphones like this Motorola MPx.

Generally, you can get good results from any camera, provided it has the features you need. Although not all of these are essential, the following features (which are discussed in detail later in this eText) are things to consider.

■ *Image size or resolution* is often overrated. Generally the larger the image a camera can capture, the sharper it will be when enlarged. However, most images are reproduced in print at between 200–300 pixels per inch so even less expensive cameras will give good 4 x 6 inch prints. Images on the Web are normally displayed at less than 100 pixels per inch, so you can get good results with images that are quite small.

■ *Image quality* is determined by the amount of compression and the file format used. Normally, cameras capture JPEG images in a variety of compressions. A few cameras also let you shoot in higher quality, uncompressed formats such as TIFF or RAW.

■ *Storage media* varies widely and the kind you use doesn't matter a great deal, with one exception. If you have more than one digital camera, or other digital device that uses storage media, it's nice to have them use the same kind so you don't need to buy more then one kind of media.

■ *Lenses* can make a huge difference. If the camera has a built-in zoom lens, it's zoom range is important as is its maximum aperture. Larger, and more expensive SLR cameras often have interchangeable lenses. The lens also determines how close you can get to a subject, or how far away.

■ *Auto focusing* doesn't always work the way you like, so manual focus is a nice feature to have.

■ *Autoexposure* is available on every camera, but aperture- and shutter-priority modes are nice to have. Exposure compensation lets you lighten or darken images when automatic exposure doesn't work the way you want. Histograms let you analyze your results with more precision.

■ *Macro mode* lets you get closer to small subjects or capture fine details on larger ones.

■ *Hot shoes* let you mount a more powerful and flexible external flash on the camera. There are also other ways to connect a flash or strobes.

■ *AC adapters* let you keep the camera on all of the time without it going into sleep mode or running down the batteries. These are ideal when using the camera to give a slide show.

■ *A monitor* lets you review your images as soon as you shoot them. The best monitors swivel and tilt so you can shoot with the camera held above your head or close to the ground.

■ *Video out connections* lets you connect your camera to a TV set so you can see larger versions of the images as you shoot them.

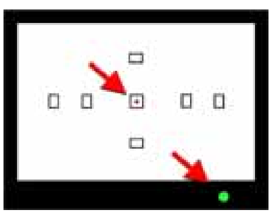
■ *A self-timer or a remote control* lets you trigger the shutter without shaking the camera and blurring the images.

■ *Video modes* let you capture short video clips that you can play back on the computer or integrate into slide shows.

■ A *diopter adjustment* lets you adjust the viewfinder so you don't need glasses when composing images.

Jump Start—Taking Photos with Auto Mode

Many digital cameras have a mode dial you turn to select various exposure modes including automatic.



Some digital cameras have more than one focus point and light the one that's being used when you press the shutter button halfway down (top arrow). When focus locks, an indicator light is often displayed (bottom arrow).

YOUR DECISIVE MOMENT

When taking a picture don't jab the shutter button! Press it gently halfway down and pause there until the camera locks focus and exposure. Only then do you press it gently the rest of the way down to take the picture.

All digital cameras have an automatic mode that sets focus and exposure for you. With the camera set to this mode, all you have to do is frame the image and push the shutter button. You'll find that this mode is great in the vast majority of situations because it lets you focus on the subject and not on the camera. Here are some things to expect with almost all digital cameras.

■ *Getting ready*. Turn the camera on and set it to auto mode. To conserve your batteries, turn off the monitor and compose your image through the optical viewfinder. If the camera has a lens cap, be sure to remove it.

■ *Holding the camera*. To take pictures, hold the camera in your right hand while supporting the lens with your left. Be sure not to block the flash, autofocus port, or lens.

■ *Framing the image*. The viewfinder shows you the scene you are going to capture—although most show only about 95% of the scene. If your camera has a zoom lens, you can zoom it in and out by pressing a button or lever or by turning a ring on the lens. Zooming out widens your angle of view and zooming in enlarges subjects. If the image in the viewfinder is fuzzy, see if the camera has a diopter adjustment dial you can use to adjust it.

■ *Autofocus*. Compose the image in the viewfinder making sure the subject that you want sharpest is in the focus area in the center of the viewfinder. Some cameras have more than one autofocus point indicated in the viewfinder or on the monitor and will focus on the closest part of the scene covered by one of the points. This lets you easily focus on a subject that isn't in the exact center of the viewfinder.

■ *Autoexposure*. Autoexposure measures light reflecting from various parts of the scene and uses these readings to set the best possible exposure. This happens at the same time focus is locked—when you press the shutter button halfway down.

■ *Autoflash*. If the light is too dim, the autoexposure system will usually fire the camera's built-in flash to illuminate the scene. If the flash is going to fire, it pops up or a flash lamp glows when you press the shutter button halfway down. If the flash lamp blinks when you press the shutter button halfway down, the flash is charging. Release the shutter button for a few seconds and try again.

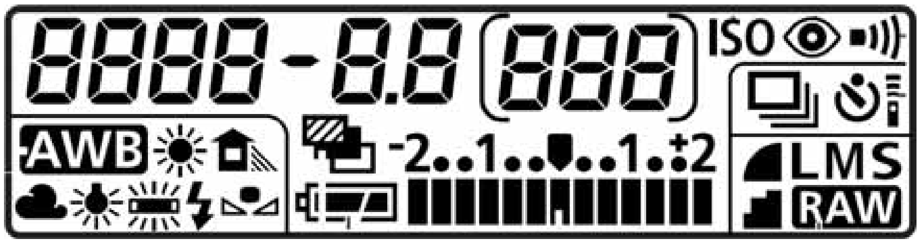
■ *Automatic white balance*. Because the color cast in a photograph is affected by the color of the light illuminating the scene, the camera automatically adjusts color balance to make white objects in the scene look white in the photo.

■ *Taking the picture*. The shutter button has two stages. When you press it halfway down, the camera locks focus and exposure and the camera beeps or an indicator lights up when this happens. (If the indicator blinks, it means the camera is having trouble focusing.) After focus and exposure are locked, press the shutter button all the way down to take the picture. When you do so, the camera may beep. As you take photos, they are first stored in the camera's internal memory called a "buffer." When the buffer is full you'll have to wait until one or more of the images has been transferred to the memory card before taking any more pictures.

■ *Quit*. When finished taking pictures, turn the camera off to conserve battery power.

Using Buttons and Menus

To operate a digital camera you use buttons and menus. When reading about digital photography you'll often encounter the term *mode*. This basically means the same as a setting. Many cameras have a small control panel that displays the current camera settings and how many pictures remain. You should make it a practice to check this control panel whenever you start shooting. If you don't you may find you've been using the wrong settings.



Control panels on many cameras indicate the current settings—often with icons.

BUTTONS

Buttons work in one of two ways depending on the camera. With some, you press the button one or more times to switch modes. On others you hold a button down while you turn a dial. Buttons are frequently marked with icons so you know their function.

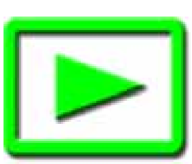
Many cameras have at least a few buttons that you use to select various settings.

If you like the classic Leica, the Minox Digital Classic Camera Leica M3 is the way to go. It's tiny but captures 2.1 megapixel images.

MENUS

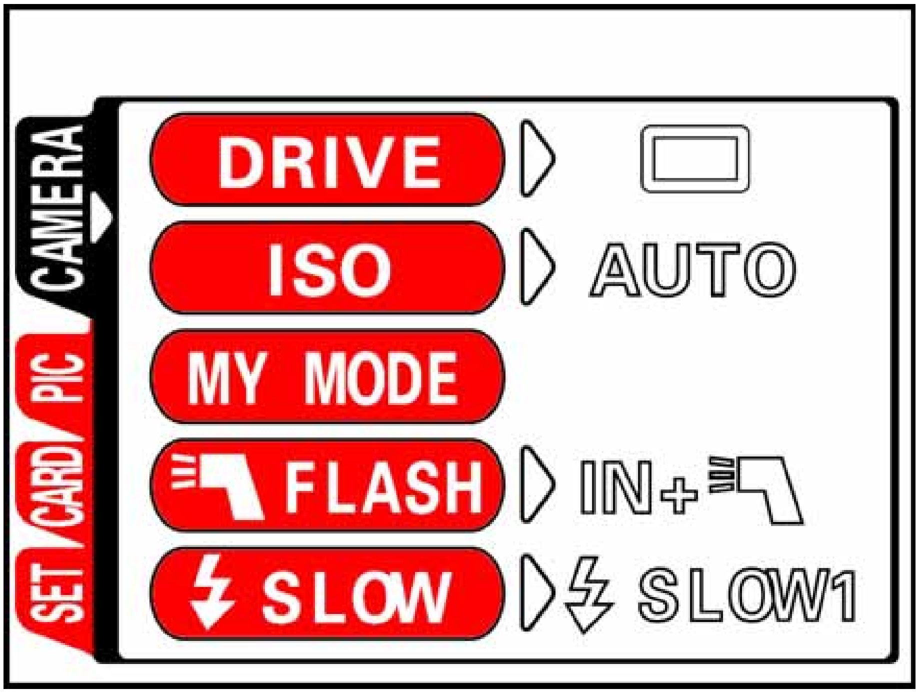
Menus are displayed on the monitor, usually when you press a menu button. The menu that's displayed depends on what mode the camera is in.

- *In shooting or record mode* you usually make settings that affect the images you capture. You've seen how you can use the auto exposure mode. That's one of the most commonly used shooting modes. There are other exposure modes, and recording modes that capture movies, panoramas, and series of images.
- *In playback mode* you can scroll through the images you have captured. You can usually display an image full-screen or display a series of smaller thumbnails. If you find images you don't want, you can delete them.



A common playback mode icon.

Menus normally have commands that you can select by pressing buttons or turning a dial on the camera.



When playing back images, or shooting them, you can usually connect your camera to a TV using a supplied cable. When playing the images back, you can give slide shows this way.

This might be a good point to introduce some good news. If you ever delete files or format a memory card by mistake, you can recover them. The first step is to stop taking pictures because new ones can overwrite the old and make them impossible to recover. Next, get a program that recovers the files. These include PhotoRescue, Digital Image Recovery, Image Recall, and Easy Recovery.

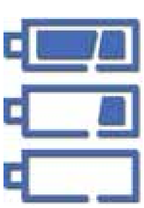
RESETTING COMMANDS

Many settings are remembered even when you turn the camera off and back on. This can really screw up photos if you don't remember to reset the command.

Good Things to Know

Most cameras store images on a removable memory card that slides into a slot on the camera.

Most cameras have an LCD panel that displays settings and an LCD monitor that displays images and menus.



Icons on the camera's control panel or monitor indicate the status of the batteries. The icons, many of which look like these, show when the battery is fully charged, getting low, and empty.

When you first start taking photos, it sometimes seems that there is too much to learn all at once. Here are some things you may want to know right off.

■ *Date and time*. The first time you use a digital camera, or if the batteries have been removed or dead for an extended period, you should enter the date and time. Having the correct date and time automatically added to each image file as you take photos will help you organize and identify your images later.

■ *Batteries*. Most digital cameras use rechargeable nickel-metal hydride or lithium batteries and come with a charger. If you can't turn on the camera, the batteries are dead or have been removed. If your batteries drain quickly, stop using the monitor to take and review pictures. If it's cold, keep the batteries or camera under your coat.

■ *Sleep Mode*. If the camera seem to be turned off, it may just have entered sleep mode. If you don't use any controls for a specified time, the camera enters this mode to reduce battery drain. To wake it up, press the shutter button halfway down, or turn the camera off and back on. After an hour or so of inactivity, some cameras shut off completely. You can often change the time it takes before the camera enters sleep mode.

■ *Indicators*. When you turn the camera on, look for a battery shaped icon that indicates when the batteries are fully charged, getting low, or run down empty and should be replaced immediately. Also look to see if there are any error messages and check how many pictures will still fit on the memory card.

■ *Saving images*. If an image is being stored when you turn the camera off, the image will be completely stored before the camera powers down. Don't open the battery or memory card access covers while an image is being saved. Doing so can not only damage the image being saved, it can also damage the card.

■ *Image review*. Some cameras will briefly display the image you just took as it is being saved. Usually you can turn this review feature on or off.

■ *Display*. You can usually adjust the brightness of the monitor. Make it brighter in bright light and dimmer in dim light. It's hard to evaluate exposure, color, and focus on these small monitors, but they are a basic guide. Always confirm your results on the computer screen.

■ *Tripods*. Many cameras have a socket so you can attach it to a tripod.

■ *TV playback*. Most digital cameras can be connected to a TV set so you can share your photos with others. You don't have to show the images you just took. You can copy images from the computer back to the flash card to give edited shows.

■ *Out of Memory*. If you can't take a picture, it may be because the memory card is full. To free up room for new pictures, move the image files to a computer and erase the memory card, delete some you don't need, or switch to a smaller image size.

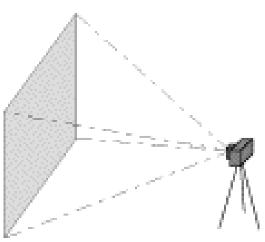
■ *Wrong settings*. If your pictures are not at all the way you expect, it may be because the camera remembered a change you made in the settings and continues to use those changed settings. Some cameras remember changes even when you turn a camera off and back on.

Composing Images

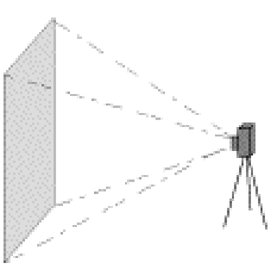
Monitors show you what the view looks like through the lens.

The best monitors are those that swivel and tilt to any angle.

With a swiveling monitor, you can shoot up at things close to the ground such as this salamander.



Landscape mode shows the image horizontally.



Portrait mode shows the image vertically.

To help you compose images, digital cameras usually have both a monitor and viewfinder. The primary roles of these two features are quite different, although there is some overlap.

MONITORS

Monitors are small LCD color displays built right into most cameras. Their size is specified in inches, and the measurement, like those of TV sets, is based on the diagonal measurement. These screens range between 1.5 and 3 inches and serve a number of useful functions:

- *Menus* are displayed on the monitor so you can change camera settings.
- *Image composition*. On many, but not all cameras, you can compose the image on the screen before you take it. SLR cameras don't let you do this because they use a mirror to bounce the image formed by the lens into the viewfinder. The image sensor only creates the image when the shutter is open.
- *Image review. You* can review an image you've taken so you know it's the way you want it. No more surprises as so often happens when you use a film camera and pick up your traditional prints.
- *Image management*. You can scroll through the images you've taken and create slide shows, delete, rotate, rename, print, protect, copy or otherwise manage them. Many cameras also display thumbnails of a group of images so you can quickly locate the image you're looking for. Most also let you enlarge the image on the monitor to zoom in on details in your photo—a great way to check sharpness. A few cameras let you view histograms of your image so you can check the tonal range.
- *Direct printing*. They let you select images for printing when you bypass the computer.

On cameras that let you compose the image on the monitor the image is taken directly from the image sensor, so it is a true TTL (thru-the-lens) view. Although you can use it to compose photos as you take them, this normally doesn't work well for a number of reasons.

- *Battery drain*. Large monitors drain batteries quickly, so it's best to keep them turned off and use the optical viewfinder for taking pictures.
- *Glare*. The image on the monitor can be difficult to read in bright sunlight.
- *Steadiness*. You may have to hold the camera at arm's length, an awkward position that tends to introduce blur into your images through camera shake.

Although the monitor should normally be turned off when taking pictures to conserve battery power, there are a few situations in which it becomes indispensable.

- *Close-ups*. When using a camera that isn't an SLR for close-ups, the monitor is a great way to compose and focus the image since it shows the scene exactly the way it will be in the image you'll capture.
- *Odd angles*. When photographing over a crowd, at ground level, or around a corner, you can compose the image without holding the camera up to your eye.

VIEWFINDERS

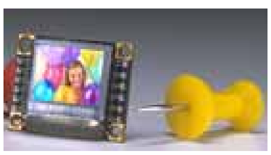
Viewfinders are ideal for following fast action as it unfolds—waiting for the decisive moment. One of their advantages is that they don't draw battery power so your batteries last much longer. But that's not all. The best optical viewfinders, known as *real-image viewfinders* are coupled to the zoom lens and show the same area covered by the image sensor. There are two kinds of viewfinder displays, optical and electronic and they either show the scene through the lens (SLR) or through a separate viewfinder window.

- *Optical viewfinders on SLR cameras* show the scene through the lens (TTL) just as 35mm SLRs do. A mirror bounces light coming through the lens into a prism that directs it out of the viewfinder. When you take a picture, the mirror swings up to let light hit the shutter and image sensor. These are true "what you see is what you get" viewfinders because you see exactly what the lens sees.

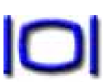
- *Optical viewfinders on point-and-shoot cameras* show the scene through a separate window that is slightly offset from the view seen by the lens. The offset view isn't a problem except in close-up photography where parallax causes you to see a view that is slightly offset from the one the lens sees so a subject centered in the viewfinder won't be centered in the image.

- *Electronic or digital viewfinders* use a small LCD monitor built into the viewfinder that shows you the same image being seen by the image sensor. Because these displays are electronic, menus can be superimposed over the scene so you can change settings without lowering the camera from your eye. This is especially useful on bright days when a monitor is hard to read because of glare. It's also advantageous for people who need reading glasses because the menu can be read without glasses.

Because an optical viewfinder is offset from the lens, what you see through the viewfinder (top) is different from the image you actually capture (bottom).



Electronic viewfinders are small flat-panel displays inside the viewfinder. Courtesy of Zight.



A common monitor icon.

In this cutaway view of the Canon Digital Rebel you can see the mirror that bounces light up into a prism for the viewfinder. The mirror swings up out of the way when you take a picture. Courtesy of Canon.

CAPTURING IMAGES

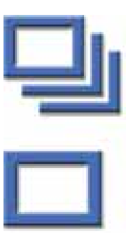
To take pictures, hold the right side of the camera with your right hand while supporting the lens or camera body with your left. Be sure not to block the flash, autofocus port, or lens. The shutter button has two stages, except on fixed focus cameras. When you press it halfway down, the camera sets focus and exposure. When you press it all the way down, you take the picture. To anticipate action shots so you can react more quickly, hold the button halfway down while focused on the scene. When you then press the button the rest of the way, the camera shoots immediately because focus and exposure have already been calculated. This speeds up your reaction time a lot, but it also drains your batteries faster. You can also press the shutter button all the way down in one action, but there will be a delay before the photo is taken.

Henri Cartier-Bresson is famous for his photographs that capture that "decisive moment" when normally unrelated actions intersect in a single instant that makes an arresting photograph. His eye-hand coordination was unrivaled, and he was able to get the results he did because he was always ready. There was never any fumbling with controls or lost opportunities. Most digital cameras have an automatic exposure system that frees you from the worry about many controls. However, these cameras have other problems that make decisive moments hard to capture. There are two delays built into digital cameras that affect your ability to respond to fast action when taking pictures.

- *The first delay* is a very brief delay between pressing the shutter button and actually capturing the image. This delay, called the *refresh rate*, occurs because the camera clears the image sensor, sets white balance to correct for color, sets the exposure, and focuses the image. Finally it fires the flash (if it's needed) and takes the picture.
- *The second delay*, the *recycle time*, occurs when the captured image is processed and stored. This delay can range from a few seconds to half a minute.

Continuous mode stores a number of images in the buffer so you can capture fast action in a series of images.

Both of these delays affect how quickly a series of photos can be taken one after another, called the *frame rate*, shot-to-shot rate, or click to click rate. If the delays are too long, you may miss a picture.



The icon on top indicates continuous mode and the one on the bottom single-shot mode.

At one time, when you took a photo, you couldn't take another one until the image was stored on the camera's storage device—usually a flash card. This takes a few moments so to speed things up, *buffers* have been added to cameras. A buffer is nothing but very fast memory, much like that in your computer or game machine. With one of these cameras, you can take another picture before the first one is saved to the storage device. In fact, you can keep pressing the shutter button to take one picture after another until the buffer becomes filled. At that point you have to wait until at least one image is saved to the storage device and its space in the buffer becomes available for another picture. Many cameras have a *continuous mode* that also uses the buffer. With the camera set to this mode, when you hold down the shutter button the camera continues taking photos one after another until the buffer is full. How quickly each photo is captured is called the *frame rate*. Many consumer cameras can capture between 2 and 3 pictures per second and professional models can go much higher than that.

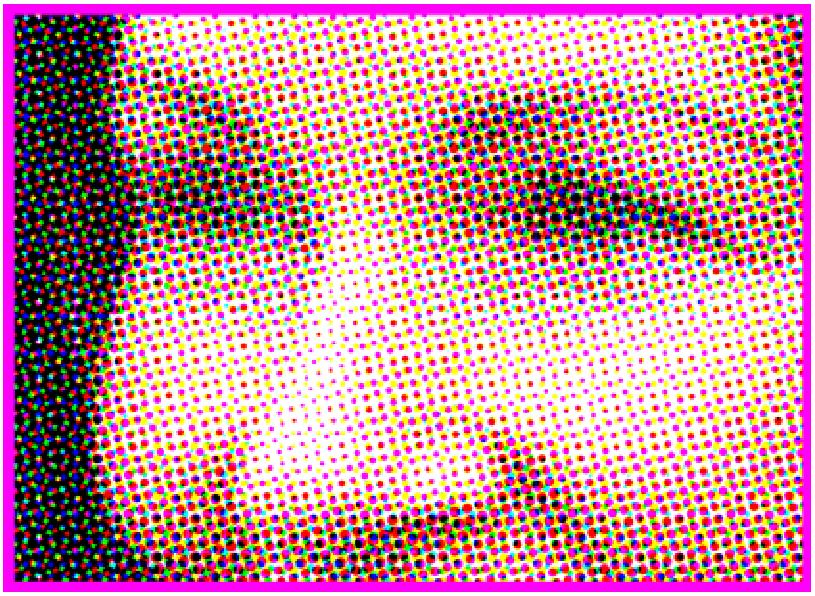
What is a Digital Photograph?

This book is about digital photography. Understanding the end product, the digital photograph, is a good place to begin understanding the entire digital photography process. It is all about dots.

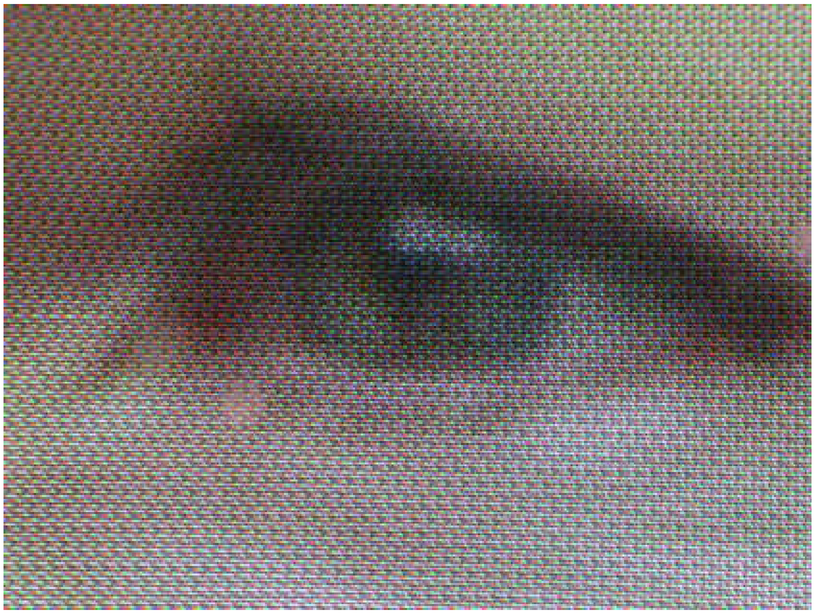
Photographs have always been made up of minute dots whether silver crystals in the film or halftone dots on a printed page. Digital cameras and scanners have just taken this dot-like quality to a new level by capturing an image's dots electronically and then using computer power to organize, edit, enhance, store, and distribute them.

Digital photographs are made up of hundreds of thousands or millions of tiny red, green, and blue dots forming what are called *picture elements*—or just *pixels*. Like the impressionists who painted wonderful scenes with small dabs of paint, your computer and printer can use these tiny pixels to display or print photographs. To do so, the computer divides the screen into a grid of pixels, each with a red green and blue dot. It then uses the values stored in the digital photograph to specify the brightness and color of each pixel in this grid—a form of painting by number. Prints are made in a similar way, but using a different set of colors. Controlling, or addressing a grid of individual pixels in this way is called *bit-mapping* and digital images are sometimes called *bit mapped images*.

This reproduction of the famous painting "The Spirit of '76" is done in jelly beans. Think of each jelly bean as a pixel and it's easy to see how dots or pixels can form images. Jelly Bean Spirit of '76 courtesy of Herman Goelitz Candy Company, Inc. Makers of Jelly Belly jelly beans.



Dots making up a newspaper photo.



Dots on the monitor making up a photo. Each dot in the image is made up of three smaller dots in the colors red, green, and blue.

Dots in a digital image.

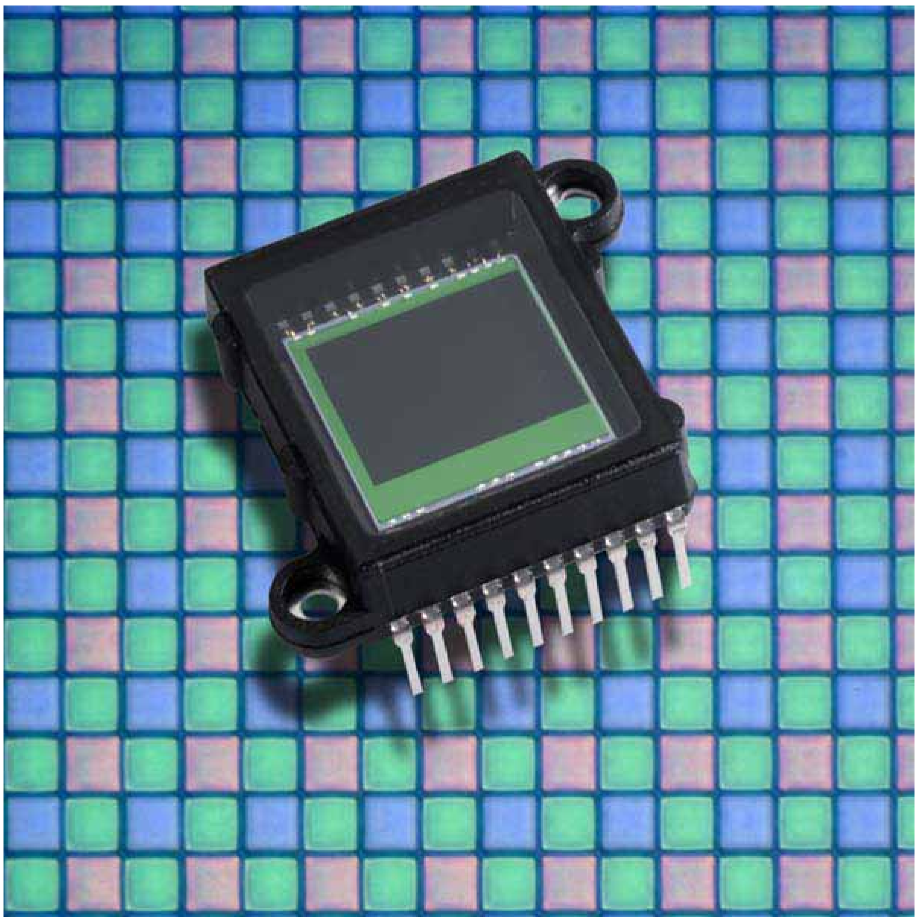
TIP

To see these dots for yourself, use a magnifying glass to examine your computer's monitor and a color photo in a magazine, book, or newspaper.

The Image Sensor

Digital cameras are very much like 35mm film cameras. Both contain a lens, an aperture, and a shutter. The lens brings light from the scene into focus inside the camera so it can expose an image. The *aperture* is a hole that can be made smaller or larger to control the amount of light that enters the camera. The *shutter* is a device that can be opened or closed to control the length of time the light is allowed to enter.

The big difference between traditional film cameras and digital cameras is how they capture the image. Instead of film, digital cameras use a solid-state device called an *image sensor*. In most, but not all, digital cameras the image sensor is a charge-coupled device (CCD). On the surface of this fingernail-sized silicon chip is a grid containing hundreds of thousands or millions of photosensitive diodes called *photosites*, photodetectors, *photoelements*, or *pixels*. Each photosite captures a single pixel in the photograph to be. Image sensors vary widely in size, ranging from fingernail size to full-frame—as large as a frame of 35mm film.

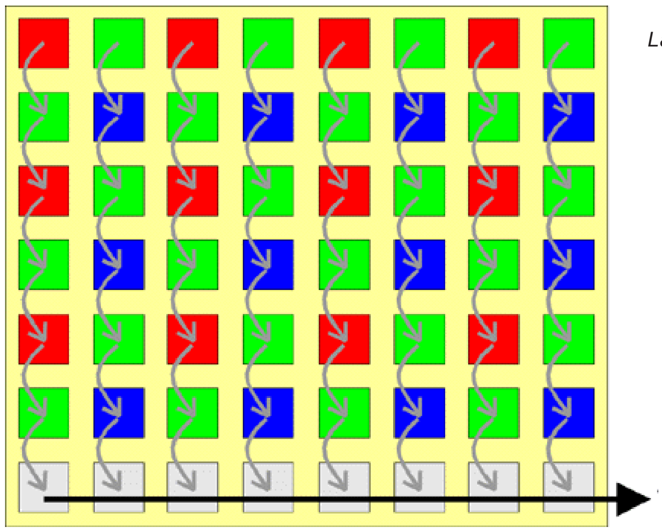


An image sensor sits against a background enlargement of its square photosites, each capable of capturing one pixel in the final image. Courtesy of IBM.

Until recently, CCDs were the only image sensors used in digital cameras. They have been well developed through their use in astronomical telescopes, scanners, and video camcorders. However, some cameras now use CMOS (pronounced *see-moss*) image sensors. Both CCD and CMOS image sensors capture light on a grid of small photosites on their surfaces. It's how they process the image and how they are manufactured where they differ from one another.

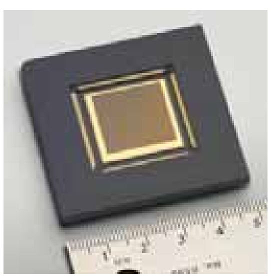
CCD IMAGE SENSORS

A charge-coupled device (CCD) gets its name from the way the charges on its pixels are read after an exposure. As soon as the exposure is complete, the charges on the first row are transferred to a place on the sensor called the *read out register*. From there, the signals are fed to an amplifier and then on to an analog-to-digital converter. Once the row has been read, its charges on the readout register row are deleted, the next row enters, and all of the rows above march down one row. The charges on each row are "coupled" to those on the row above so when one moves down, the next moves down to fill its old space. In this way, each row can be read—one row at a time.



The CCD shifts one whole row at a time into the readout register. The readout register then shifts one pixel at a time to the output amplifier.

CMOS IMAGE SENSORS



Foveon's 16.8 million pixel image sensor, manufactured using CMOS process technology.

Image sensors are manufactured in factories called wafer foundries or fabs where the tiny circuits and devices are etched onto silicon chips. The biggest problem with CCDs is that they are created in foundries using specialized and expensive processes that can only be used to make other CCDs. Meanwhile, more and larger foundries across the street are using a different process called Complementary Metal Oxide Semiconductor (CMOS) to make billions of chips for computer processors and memory used in your notebook or desktop computer. CMOS is by far the most common and most efficient chip-making process in the world. The latest CMOS processors, such as the Pentium 4, contain an amazing 42 million active elements. Using this same process and the same equipment to manufacturer CMOS image sensors cuts costs dramatically because the fixed costs of the plant are spread over a much larger number of devices. As a result of these economies of scale, the cost of fabricating a CMOS wafer is less than fabricating a similar wafer using a specialized CCD process. Costs are lowered even farther because CMOS image sensors can have processing circuits created on the same chip at the time it is made. When CCDs are used, these processing circuits must be on separate chips.

Early versions of CMOS image sensors were plagued with noise problems, and used mainly in low-cost cameras. However, great advances have been made and CMOS image sensors are now used in some of the finest professional cameras.

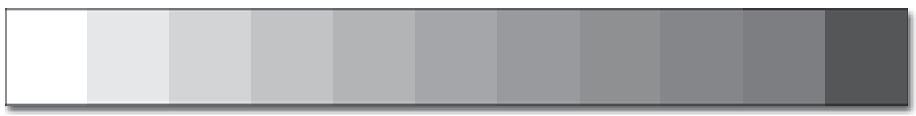
Digital Color

When you press the shutter button of a digital camera, a metering cell measures the light coming through the lens and sets the aperture and shutter speed for the correct exposure. When the shutter opens briefly, each pixel on the image sensor records the brightness of the light that falls on it by accumulating an electrical charge. The more light that hits a pixel, the higher the charge it records. Pixels capturing light from highlights in the scene will have high charges. Those capturing light from shadows will have low charges.

When the shutter closes to end the exposure, the charge from each pixel is measured and converted into a digital number. This series of numbers can then be used to reconstruct the image by setting the color and brightness of matching pixels on the screen or printed page.

It may be surprising, but pixels on an image sensor can only capture brightness, not color. They record only the *gray scale*—a series of 256 increasingly darker tones ranging from pure white to pure black. How the camera creates a color image from the brightness recorded by each pixel is an interesting story.

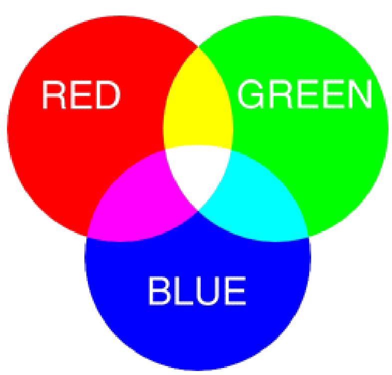
The gray scale contains a range of tones from pure white to pure black.



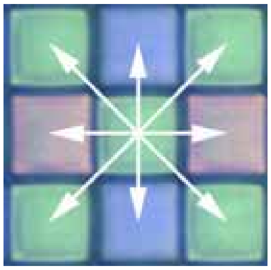
When photography was first invented, it could only record black and white images. The search for color was a long and arduous process, and a lot of hand coloring went on in the interim (causing one photographer to comment "so you have to know how to paint after all!"). One major breakthrough was James Clerk Maxwell's 1860 discovery that color photographs could be created using black and white film and red, blue, and green filters. He had the photographer Thomas Sutton photograph a tartan ribbon three times, each time with a different color filter over the lens. The three black and white images were then projected onto a screen with three different projectors, each equipped with the same color filter used to take the image being projected. When brought into alignment, the three superimposed images formed a full color photograph. Over a century later, image sensors work much the same way.

Colors in a photographic image are usually based on the three primary colors red, green, and blue (RGB). This is called the *additive color system* because when the three colors are combined or added in equal quantities, they form white. The RGB system is used whenever light is projected to form colors as it is on the display monitor (or in your eye).

RGB uses additive colors. When all three are mixed in equal amounts they form white. When red and green overlap they form yellow, and so on.



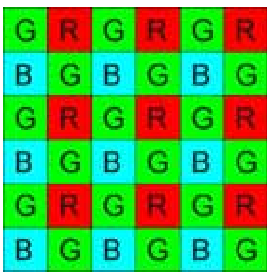
These two photos of the town I live in, were taken around 1900 before color film was widely available. Published as lantern slides, you can see what a difference hand coloring makes.



Here the full-color of the center green pixel is about to be interpolated using the colors recorded by the eight surrounding pixels.

Since a full-color image can be created from red, green, and blue light; placing red, green, and blue filters over individual pixels on the image sensor can create color images just as they did for Maxwell in 1860. Through a process called *interpolation*, the camera computes the full color of each pixel using the color it captured directly through its filter, and the other two colors captured by the pixels around it through their differently colored filters. ("I'm bright red and the green and blue pixels around me are also bright so that must mean I'm really a white pixel.") This step is computer intensive since comparisons with as many as eight neighboring pixels are required to perform this process properly.

When you view a natural scene, or a well done color photograph, you are able to distinguish millions of colors. Digital images can approximate this color realism, but whether they do so on your system depends on its capabilities and its settings. The number of colors in an image is referred to its *color depth*, pixel-depth, or bit depth. Older PCs were stuck with displays that showed only 16 or 256 colors, however, all newer systems can display what's called 24-bit True Color. It's called True Color because these systems display 16 million colors, about the number the human eye can distinguish.



Each pixel on an image sensor has red, green, and blue filters intermingled across the photosites in patterns designed to yield sharper images and truer colors. The patterns vary from company to company but the most popular is the Bayer mosaic pattern shown here. There are twice as many green filters as the other colors because the human eye is more sensitive to green and therefore green color accuracy is more important.

Why does it take 24 bits to get 16 million colors? It's simple arithmetic. To calculate how many different colors can be displayed, raise the number 2 to the power of the number of bits used to display them. For example, 8-bits gives you 256 colors because 2^8=256 and 24 bits gives you 16 million because 2^{24} is almost 17 million.

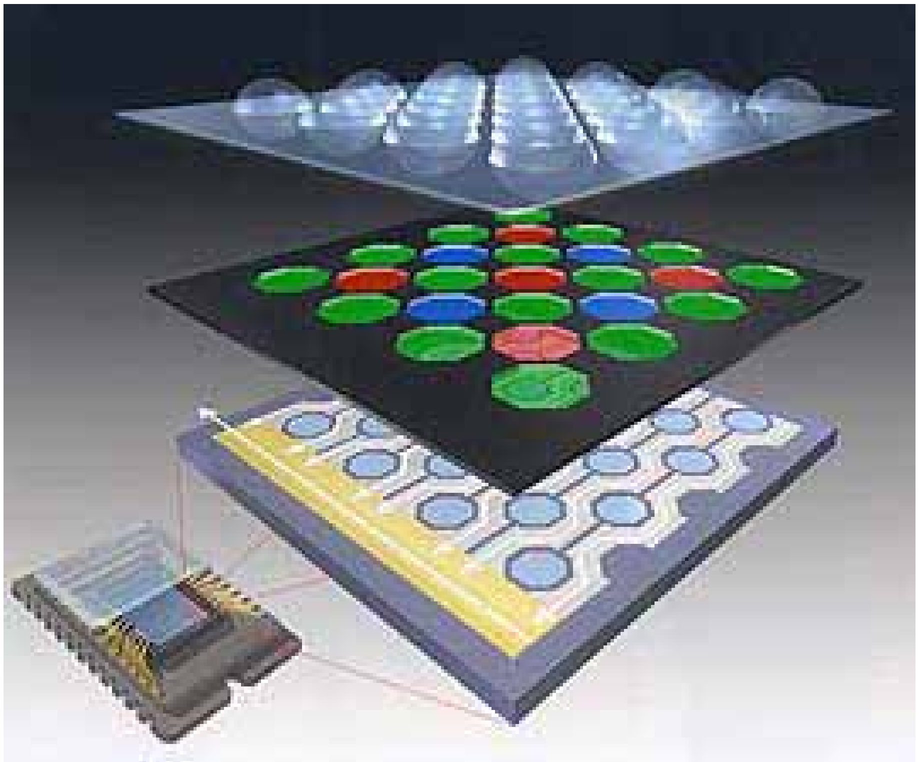
Some digital cameras (and scanners) can capture images using 48 bits. The number of possible colors for these images is astronomical—281 trillion. These extra colors are not used in JPEG images because that format doesn't support 48 bit color. However, there are image formats such as RAW and TIFF which you'll learn about later that can preserve all of these colors—not so much to display or print them, but to give really fine gradations when editing and adjusting the images into their final form.

Here's a table to show you some other possibilities.

NAME	BITS PER PIXEL	FORMULA	NUMBER OF COLORS
Black and white	1	2^1	2
Windows display	4	2^4	16
Gray scale	8	2^8	256
256 color	8	2^8	256
High color	16	2^{16}	65 thousand
True color	24	2^{24}	16 million

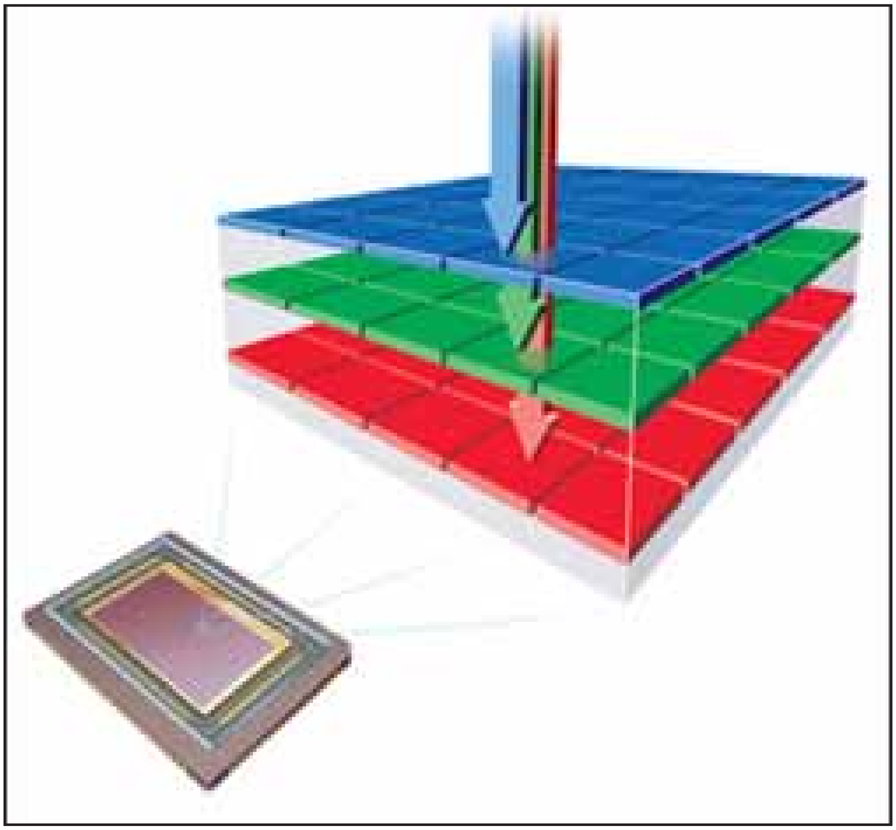
TIP: CHECKING YOUR SYSTEM

You may have to set your system to full-color, it doesn't happen automatically. To see if your Windows system supports True Color, display Window's *Start* menu, click *Settings*, and then click *Control Panel*. Double-click the *Display* command to open the Display properties dialog box. Click the *Settings* tab on the dialog box and check the *Colors* setting.



A CCD is like a three-decker sandwich. The bottom layer contains the photosites. Above them is a layer of colored filters that determines which color each site records. Finally, the top layer contains microlenses that gather light. Courtesy of Fujifilm.

Unlike traditional image sensors that record just one color per pixel Foveon's X3 can capture red, green and blue light at each and every pixel. The X3 features three layers of photodetectors embedded in silicon that take advantage of the fact that red, green and blue light penetrate silicon to different depths—forming a full-color image sensor.



A Foveon X3 image sensor has three layers of photodetectors to take advantage of the fact that red, green and blue light penetrate silicon to different depths. Courtesy of Foveon (www.foveon.com).

Selecting an Image Size

> **TIP**
>
> Images sizes are discussed in detail in Chapter 12 “Pixels and Images.”

When shooting photos, the image size you use to capture it has a big effect on how large it can be displayed on the screen or printed. Generally, the best approach is to shoot at the largest available size. You can always make an image smaller in a photo-editing program, but you can never make it larger and retain the original quality.

The relative size of a digital image is determined by the device used to display it. However, the absolute size of the image is determined by the number of pixels used to create it (sometimes referred to as *resolution* or *image size*). More pixels in an image add detail and sharpen edges.

The size of a digital image is specified in one of two ways—by its dimensions in pixels or by the total number of pixels it contains. For example, the same image can be said to have 3072 × 2048 pixels (where “×” is pronounced “by” as in “3072 by 2048), or to contain 6.29 million pixels (3072 multiplied by 2048). Since the term “megapixel” is used to indicate 1 million pixels, an image with 6 million pixels can also be referred to as a 6 megapixel image.

Image sizes are expressed as dimensions in pixels (3072 × 2048) or by the total number of pixels (6,291,456).

> **TIP**
>
> Enlarging digital images is usually avoided because the results are not that good. However, there are now programs available that do a very good job at this single task. One of the leaders in this area is pxl SmartScale from Extensis.

The number of pixels in a digital image is important because if you enlarge an image enough, it begins to loose sharpness and eventually the pixels begin to show—an effect called *pixelization*. This is not unlike traditional silver-based prints where grain begins to show when prints are enlarged past a certain point. The larger the image is to begin with—the more pixels that it contains—the larger it can be displayed or printed before pixelization occurs. However, with even inexpensive cameras capturing 2 and 3 megapixel images, most images will never bump up against this limit.

One advantage of larger images is seen when editing. Changes to such aspects as color balance, hue, saturation, contrast, and brightness are more effective on larger images because there is more image data to work form. After making these adjustments, you can reduce the file to the needed size.

When a digital image is displayed at the correct size for the number of pixels it contains (left), it looks like a normal photograph. When enlarged too much (right), its square pixels begin to show.

One advantage of a large image size is that it gives you the freedom to crop the image and still have it be a usable size.

As you might expect, all other things being equal, costs rise with a camera's image size. Although larger image sizes can give you sharper and better enlargements, they can also create problems. For example, more pixels means larger image files. Not only are larger files harder to store, they take longer to transfer, process, and edit and are often far too large to e-mail or post on a Web site. Smaller image sizes such as 640 x 480 are perfect for Web publishing, e-mail attachments, small prints, or as illustrations in your own documents and presentations. For these uses, higher resolutions just increase file sizes without significantly improving the images.

Here are some rules of thumb about what image sizes you need for certain outputs.

■ *On the Web*, images are displayed on screens that have resolutions of 1280 x 1024, 1152 x 864, 1024 x 768, 800 x 600, or 640 x 480. A few years ago, a 1024 x 768 monitor was unusual so most people in the industry settled on assuming that the lowest common denominator for screen sizes was 640 x 480 or, at best 800 x 600. For this reason, images should be of similar or smaller sizes—no more than 800 pixels wide (on eBay's Picture Services the maximum allowable size is 800 pixels wide). This ensures that images will display correctly on the vast majority of computers. If an image is too large, users will not be able to see it all at once and will be forced to scroll around it. If too small, details will be lost. Size also affects the speed with which images travel over the Web. Smaller (and more compressed) images travel faster so people see them more quickly.

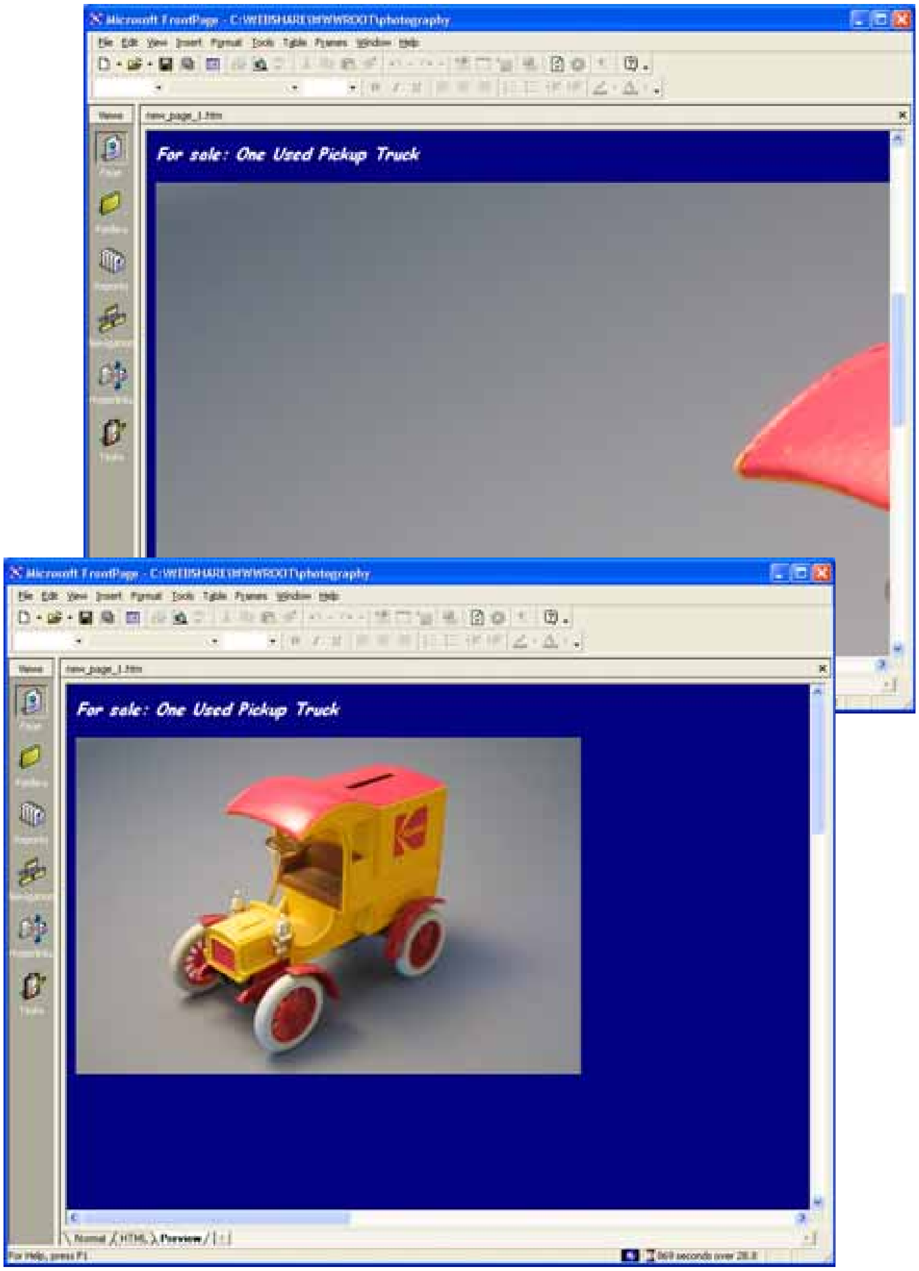
■ *For laser and inkjet printers* you need between 200–300 pixels or dots per inch. If your camera can capture images that are 2400 pixels wide, you can expect good results when prints are between 8 and 12 inches wide.

■ *When images are printed on a printing press*, as they might be for a catalog, the pixels in the image are printed as dots on the page. Photographic prints that are to be printed on a press are first "screened." To do this, a clear glass plate with scribed grid lines is laid on the photograph and then a picture is taken of the photograph through the screen. The scribed lines on the glass plate break the image up into dots called a "halftone." The negative is then used to create a printing plate used on the press. Today this process is usually done digitally, but it has the same result. The fineness of the screen used determines the quality of the printed image. Most photographs are screened with somewhere between 85 lines per inch (lpi) in newspapers to 200 lpi in high quality art books. For the best results, your images need to have 1.5 times as many pixels per inch as the screen's lpi (confirm with your printer). For example, if the printer is using a 150 lpi screen, your image must have at least 225 pixels per inch. This means to print a 4-inch wide image in a catalog, you need to have an image width of at least 900 pixels.

The number of pixels in an image, sometimes referred to as its resolution, determines the size of the image when it's displayed on the screen or how large a print can be made that is still sharp.

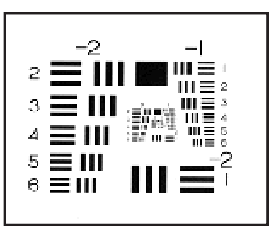
Here are the relative sizes of two images sized to be printed or displayed at 4 x 5 inches. The larger image (1500 x 1200 pixels) will print at 300 dots per inch. The smaller one (360 x 288) will be displayed on the screen at 72 dpi. Although greatly different in the number of pixels they contain, the different output devices will render them the same size.

If an image is too large for a screen (top-right), the viewer will have to scroll around it to see it. When sized correctly (bottom-left) they can see the entire image.



SCREEN RESOLUTIONS

CGA 320 x 200
EGA 640 x 350
VGA 640 x 480
SVGA 800 x 600
XGA 1024 x 768
SXGA 1280 x 1024
WXGA 1366 x 768
SXGA+ 1400 x 1050
UXGA 1600 x 1200
WSXGA+ 1680 x 1050
WUXGA 1920 x 1200
QXGA 2048 x 1536
QSXGA 2560 x 2048
QUXGA 3200 x 2400
WQUXGA—3840 x 2400

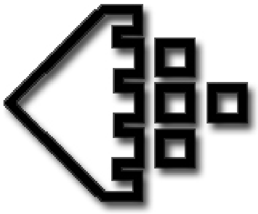


Test charts have pairs of lines at various spacings

THE COLLISION OF TWO WORLDS

The term "resolution" was introduced in the computer world as a way to describe screen displays. In the early days, a screen would have a CGA or VGA resolution. Later, other names were introduced to describe even higher resolutions. The terms were used to describe the number of pixels on the screen. For example, the VGA screen had 640 pixels across the screen and 480 down (640 x 480). No one was concerned about the use of the term "resolution" at the time it was introduced. It's only when photography became digital that another group of people entered the scene with a totally different use of the term. To photographers, or anyone in optics, resolution describes the ability of a camera system to resolve pairs of fine lines such as those found on a test chart. It's an indicator of sharpness, not image size

Selecting an Image Quality



The almost universally recognized icon for image quality.

When capturing images, there are a number of choices you can make about compression ratios and file formats. Your choices determine image quality and the size of the files you create.

FILE COMPRESSION

Image files are huge compared to many other types of computer files. For example, a low-resolution 640 x 480 image has 307,200 pixels. Since each pixel requires 24 bits (3 bytes) to store color information, a single image takes up about a megabyte of storage space. As the resolution increases, so does the file size. At a resolution of 1600 x 1200, each 24-bit picture takes up over 5.7 megabytes. To make image files smaller and more manageable, digital cameras use a process called *compression*. Compressing images not only let's you save more images on a camera's storage device, it also allows you to download and transmit them more quickly.

During compression, data that is duplicated or that has no value is eliminated or saved in a shorter form, greatly reducing a file’s size. For example, if large areas of the sky are the same shade of blue, only the value for one pixel needs to be saved along with the locations of the other pixels with the same color. When the image is then edited or displayed, the compression process is reversed. There are two forms of compression—*lossless* and *lossy*—and digital cameras use both forms.

- *Lossless compression*. When an image compressed with lossless compression is uncompressed, its image quality matches the original source—nothing is lost. Although lossless compression sounds ideal, it doesn’t provide much compression and files remain quite large. For this reason, lossless compression is used mainly where detail is extremely important, as it is when planning to make large prints or use high-quality printing. Lossless compression is offered by some digital cameras in the form of TIFF and RAW file formats.

- *Lossy compression*. Because lossless compression isn’t practical in many cases, all popular digital cameras offer a lossy compression (rhymes with “*bossy*”). This process degrades images to some degree and the more they're compressed, the more degraded they become. In many situations, such as posting images on the Web or making small to medium sized prints, the image degradation isn't obvious. However, if you enlarge an image enough, it will show. The most common lossy file format is JPEG.

FILE FORMATS

You have a number of choices when it comes to file formats. All digital cameras store still images in the JPEG format, but some also let you select TIFF or CCD RAW. A forth format, GIF, has limited uses. Let’s look at all four formats.

- *JPEG*, named after the Joint Photographic Experts Group and pronounced "*jay-peg*," is by far the most popular format for photographic images. In fact, most cameras save their images in this format unless you specify otherwise.

A JPEG image is stored using lossy compression and you can vary the amount of compression—perhaps to reduce files to 1/4, 1/8, or 1/16 their original size. This allows you to choose between lower compression and higher image quality or greater compression and poorer quality. Most cameras give you two or three choices equivalent to good, better, best although the names vary. JPEG compression is performed on blocks of pixels eight on a side. You can see these blocks when you use the highest levels of compression and then greatly enlarge the image.

- *TIFF* (Tag Image File Format) has been widely accepted as an image format. Because of its popularity in digital photography, the format has been revised to TIFF/EP (Tag Image File Format—Electronic Photography). TIFF/EP may be stored by the camera in uncompressed form, or using JPEG compression. TIFF/EP image files are often stored in a “read-only” fashion to prevent accidental loss of important information contained within the file. This is why you sometimes can’t delete them once they are on your computer without first turning off the file’s read-only attribute.

- *CCD RAW* format stores the data directly from the image sensor without first processing it. This data contains everything captured by the camera. In addition to the digitized raw sensor data, the RAW format also records color and other information that is applied during processing to enhance color accuracy and other aspects of image quality. Instead of being processed in the camera, where computing power and work space is limited (imagine Scarlett O’Hara trying to change into a Civil War era ball gown in a small closet), the raw data is processed into a final image on a powerful desktop computer. The increased computing power and space to work in can make a significant difference in the results. You don’t get the artifacts (image flaws) that sometimes appear in JPEG images. In addition, you can save the original raw data and process it with other software, or in different ways. This is unlike a JPEG image where data are permanently changed or deleted during processing in the camera and can never be recovered.

In addition to image quality, RAW files have other advantages. Their files are approximately 60% smaller than uncompressed TIFF files with the same number of pixels, and the time you have to wait between shots is shorter since processing time in the camera is shorter.

CHOOSING A FORMAT

If your camera lets you choose a file format and compression ratio you should always choose those that give you the highest quality. If you decide later that you can use a smaller image or greater compression, you can do so to a copy of the image using a photo-editing program. If you shoot the image at a lower quality setting, you can never really improve it much or get a large, sharp print if you want one. The only problem with this approach has to do with file sizes. The highest quality images can be 15 or more megabytes in size. These are almost impossible to send to anyone by e-mail and are slow to open, edit, and save on even a powerful desktop computer. In addition, when you shoot images of this quality you often have to wait a long time between shots because the camera is tied up processing the last image you took. Most photographers use a compromise and shoot in the highest quality JPEG format. Even these image files can be 2–5 megabytes in size on the latest cameras.

When you open an image to work on it, you should first save it so you are working on a copy and preserving the original image unchanged. Save it in a loss-free format such as TIFF. Even better, your photo-editing program may have its own native format that preserves information that no other format will. Use this format while editing. If you want a specific format for the finished image, save a copy of it in that format as the final step. In particular, don't repeatedly close, open, and resave JPEG original images. Every time you open one of these files, and then save it again, the image is compressed. As you go through a series of saves and reopens, the image becomes more and more degraded—an image quality death spiral. (An image is compressed only once during a single session, no matter how many times you save it, so save it frequently to avoid losing your edits.) Also, when you save an image as a JPEG, the image on the screen won't show the effects of compression unless you close the file and then open the saved version.

Many digital photos end up on the Web or attached to e-mail, so they are viewed on the screen. For these purposes, small, heavily compressed JPEG files that are easy to view or send over the Internet are favored. For the highest quality printed images, TIFF or RAW formats should be used. RAW is especially useful when accurate color rendition is essential.

The top photo is a TIFF image that hasn't been compressed. The bottom image is a JPEG image that has been repeatedly compressed.

Chapter 2
The Digital Darkroom

CONTENTS

Digital photography doesn't have a darkroom of course, but everyone has been hard-pressed to come up with a name for the place where digital photos are transferred from the camera, reviewed, organized, stored, edited, and finally printed and shared. Until a more descriptive name is widely accepted, many people refer to this space and the processes that occur in it as *the digital darkroom*. Much of what goes on in the digital darkroom is done with a program such as Photoshop or Photoshop Elements and hardware like your computer and printer. However, there are lots of other tasks and tools involved in the digital darkroom process. Images that you capture are initially stored by the camera as files on some form of memory device. When you are finished shooting, or when the storage device becomes filled, you move the image files to a more permanent form of storage—usually the computer's hard drive. How you organize your files and folders on the computer makes a huge difference in how easy it is to find your images at a later date when you want to edit, print, or distribute them. As your collection grows, you'll want to manage it more carefully and may want to move some or all of your images to a more permanent form of archival storage such as a CD or DVD. In this chapter we introduce you to all of these topics including photo-editing and color management.

Storing Images in the Camera

Most cameras store images on a removable memory card that slides into a slot on the camera. Courtesy of SanDisk.

With traditional cameras, film is used both to record and store the image. With digital cameras, separate devices perform these two functions. The image is captured by the image sensor, then stored in the camera on a storage device as an image file—usually with the filename extension .JPG. The kind of device you use to store images is determined by your camera. Most accept one, or maybe two kinds of storage devices. However, there are some choices you may be able to make—at least if your camera uses flash cards.

One great thing about these storage devices is that more and more printers, TV sets, and other devices are being designed to accept them right out of the camera so you can display and share them without a computer.

TYPES OF STORAGE DEVICES

Almost all digital cameras now use some form of removable storage device, usually flash memory cards, but occasionally small hard disks, or even CDs—and DVDs will be close behind.

CARD TYPES

- CompactFlash™ (CF) Type I and II
- Micro Drive
- SmartMedia™ (SM)
- MemoryStick™ (MS)
- MemoryStick™ Pro (MS Pro)
- SecureDigital™ (SD)
- MultiMedia-Card™ (MMC)
- NAND Flash (NF)
- xD Picture-Card™ (xD)
- TransFlash

■ *Flash memory cards* are the most common storage device for digital cameras. These devices use solid state chips to store your image files so they consume little power, take up little space, and are very rugged. The confusing array of incompatible flash memory cards includes those listed in the box to the left. The main differences among the cards, from a photographer's perspective, are their physical dimensions, the number of images they can store, and their speed.

■ *Hard disks,* such as Hitachi's Microdrive, are small enough to be plugged into a Type II CompactFlash slot. (Type I CompactFlash slots are thinner.) These disks are relatively inexpensive and have huge storage capacity. However, they are slower than flash cards and consume more power—shortening your battery life. They may also be more prone to damage if you drop them onto rocks, but the same can be said of your lens (or head). How often are you really dropping such important things?

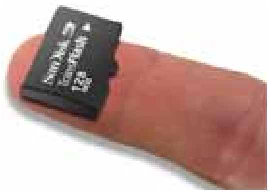
■ *CD-R or CD-RW discs* are widely used to archive captured images, but some cameras use them as removable storage devices right in the camera. These 3-inch pocket or mini CD discs are smaller than the more familiar standard CDs, but they can be played in any standard CD drive. These CDs store a lot of image files very inexpensively, but they are slow and since the discs are relatively large, cameras that use them must also be large. It's just a matter of time until a camera comes along that uses DVD discs.

CHOOSING STORAGE DEVICES

Flash memory cards come in a variety of shapes and sizes. Courtesy of SanDisk.

Whatever its form, removable storage lets you remove one device when it's full and insert another. The number of images you can capture is then limited only by the number of storage devices you have, the capacity of each, and the size of your image files. If your camera uses an optical disc for storage, there isn't much to think about when you buy new discs. However, when using storage cards, there are choices to be made. Here are some things to think about, when considering these cards:

■ *Capacity*. The size of digital image files is increasing as the pixel count climbs. The latest 8 megapixel cameras create files that are over 3 megabytes. To estimate how many will fit on a given storage device, divide the average



Memory cards keep getting smaller as shown here with this 128 Megabyte TransFlash Card Courtesy of SanDisk.

file size created by your camera into the device's storage capacity. A 64 megabyte device will store at most thirty-two 2 megabyte images and twelve 5 megabyte images. The number of images you can store is important because once you reach the limit, you have no choice but to quit taking pictures or erase some existing ones to make room for new ones. How much storage capacity you need depends partly on what you use the camera for. If you're used to shooting 5 or 6 rolls of standard film on vacation, your memory devices better be able to store the same number of images or you'll be out of luck. (In the next section we discuss solutions to this problem.)

■ *Adapters*. Because there are so many types of cards, many devices have slots for only the most popular types—usually the larger CompactFlash slot popular in cameras, or the even larger PC Card slot (also called a *PCMCIA slot)* popular on notebook computers. With the aid of an adapter, any smaller card can be inserted into these larger slots. The smaller card fits into the adapter and the adapter then fits into the slot.

The Hitachi Microdrive fits a CF-II slot and is a marvel of engineering.

.

■ *Versions*. Some flash cards come in more than one version. For example, CompactFlash™ (CF) cards come in two forms: Type I and Type II with the only difference between them being their thickness. Because it's the thinner of the two, a Type I card will fit in both a Type I or Type II slot. The thicker Type II card will only fit in a thicker Type II slot.

n *Popularity*. The more popular a storage card is, the more of them are made and the less each costs. Also, popular cards are used in more camera models, so the chances are that you will be able to find a second camera, or a new model that supports your cards if you have the right type. At the time this book is being written SmartMedia is on its way out, SD Cards are on their way in, and CompactFlash remains dominant at the higher end. MemorySticks are successful but used only in Sony products.

Sony has been one of the leaders in cameras using optical storage in the CD Mavica line. Courtesy of Sony.

FORMATTING STORAGE DEVICES

Because a digital camera storage device acts just like a computer disk, it has to be formatted before you can use it. This is usually a onetime activity and some cards, including those supplied with your camera, come with this already done. However, even then, you may have to reformat a storage device at some point if it develops problems. Just be aware that formatting a storage device for your camera deletes all of the files on it, just as it does on your computer. To prevent you from formatting it accidentally, some cards can be write-protected. For example, to write-protect a SmartMedia card you place a sticker over the round write-protect area on the face of the card. On a MemoryStick, you slide a switch. When protected, you can't save new images to the card, move or delete images, or format the card. The images are totally protected, but you can view and copy them.

Cards are easy to misplace and the smaller they are, the easier they are to lose. If you don't find a way to store them safely, you're sure to run some through the washing machine forgotten in a shirt or pants pocket. One way to keep them safe is to use an inexpensive storage case.

Formatting a camera's card, or any disk for that matter, divides the card into sections that can be located by the operating system when saving and opening files. It's analogous to dividing an empty pasture into streets and lots and then assigning a street address to every lot so mail can be delivered at a later time. Formatting also creates a special section on the card called a File Allocation Table (FAT) that acts as an index so the operating system knows where each part of each file is located, its name, size, and so on.

Transferring Photos

The PC Card (PCMCIA) slot has become almost universally accepted. To use other memory devices in a PC Card slot, you use an adapter. Courtesy of SanDisk.

Until recently, digital photographers almost always transferred their images directly to a computer, but times are changing. With camera phones there is a variety of ways to move images among phones, printers, computers, and even TVs. In this section we discuss the alternatives—not all of which are available on every phone or every service.

CARD READERS

Card readers contain slots and connect to the computer with a cable. Some have slots for one kind of card, others have slots for a variety of types. In either case you can also use adapters to match cards and slots. These readers connect to the computer using a USB or FireWire port, both of which come in older and slower and newer and faster versions—USB 1.1 and 2.0 and FireWire 400 and 800. Almost all newer computers have a number of USB 2.0 ports. The faster FireWire ports are built into Apple computers and are optional on PCs.

More and more products now contain their own card slots. Printers at your local drug store, home printers, hard drives, and even TV sets are sporting them. The goal of these devices is to get the computer out of the center of digital photography, although computers increasingly have their own slots too.

The Universal Reader reads SmartMedia, CompactFlash, MemoryStick, and SD cards. Courtesy of OnSpec Electronics.

DATA CABLES

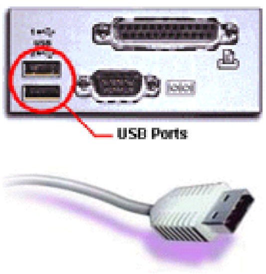
Many camera phones have a cable connection that you use to directly connect them to a computer or other device. In some cases, it's an old-fashioned serial cable but for images of any size and quality it will be a USB cable. USB cables come in a variety of configurations. The end that plugs into the computer is always the same, but the end that connects to the camera varies from model to model. USB plugs and receptacles are colored coded inside the connector to guide you when plugging them in.

One take on the data cable is the docking station. Because many early digital cameras did not have removable storage devices, the docking station was introduced. These devices have a small base that holds the camera and a cable that connects the base to the computer. (The connection options are the same as for card readers.) When ready to download files, you just put the camera in the docking station where its batteries are also charged. These devices have gone out of fashion since almost all digital cameras have some form of removable storage device. However, since they give a camera phone a home and keep its batteries charged, they may yet see another day.

Some home printers and kiosks at photo stores have slots that accept cards directly from your camera. This lets you print images without a computer. Courtesy of Hewlett Packard.

MOBILE CONNECTIONS

Camera phones use a technology called *Multimedia Messaging Service* (MMS) to send photos, videos, recorded sounds, and text between compatible phones and the recipient can view them immediately. When you send an MMS message to a phone that isn't compatible with yours, it is stored by your operator and a text message is sent to the intended recipient along with a link they can click to view the message from their computer or other Web-enabled device. One way around incompatible phones is to send your photos to an on-line album so the other person can download them to their phone from there.



A USB plug (bottom) and receptacle (top).

WARNING

USB hubs can introduce problems when connecting digital cameras or card readers. If you experience any problems, plug your camera or card reader directly into the computer.

It's easy to send a MMS message. You usually select a photo or video, select a phone number (or e-mail address), type a personal message, and click Send. Some phones let you preview your message after you create it so you are sure it's the way you want it. When sending multimedia messages to other phones, unless you know better, keep the images small and video clips short so you don't tie up the recipient's phone with a long download.

Some networks and phones will only send small versions of your photos over MMS. For example, a camera that takes photos at 640 x 480, may send one only half that size. However, you can often send larger images by e-mail, and it may even be cheaper. Of course, it all depends on your camera phone and carrier. Eventually, as network speeds improve, you'll be able to send larger files, including longer video clips.

When sending photos, videos, recorded sounds, and text to someone without a phone, you can e-mail them as attachments. If the phone supports Wi-Fi you can choose between sending the e-mail over the cell network or over the Internet. When the e-mail arrives at the recipient's end, he or she can view the attachments or save them into separate files. Once saved, the attachments can be edited, printed, or shared just like other files on the system.

Data networks are run by some operators parallel to their cell net. For example, T-Mobile Internet can be used by your smartphone, notebook, or any other Web-enabled device. Verizon Wireless is rolling out a wireless technology called EV DO that is as fast as a cable connection. These connection are available across the entire cell network, unlike Wi-Fi connections that are only available at sparsely distributed access points.

LOCAL WIRELESS CONNECTIONS

The Bluetooth® logo.

Camera phones are driving a big change in digital photography. Although they are designed to exchange images over the cellular network, they are also introducing new wireless ways to transfer the images they capture to computers, printers, and other devices. You can expect to see many of these features added to dedicated digital cameras.

- *Bluetooth®*, inexplicably named after Herald Bluetooth a 10th Century Danish king, is a relatively slow wireless technology—much slower than Wi-Fi. Initially developed to replace all of the cables hanging off your desktop, to connect wireless headsets, and to connect to the hands-free calling system in some cars, Bluetooth is also finding a home in photography. Photo kiosks are being equipped with Bluetooth so you can beam your photos to the printer. You can also exchange them with other Bluetooth devices including cameras, computers, and even TVs. There are cards and adapters that let you use Bluetooth to wirelessly transfer images from your Bluetooth enabled device to your computer.

The Concord Eye-Q is a 2 megapixel camera with wireless Bluetooth capability.

Since Bluetooth devices communicate using radio waves, your Bluetooth devices do not need to be in direct line-of-sight. The two devices only need to be within a maximum of 30 feet (10 meters) of each other, although obstructions such as walls or interference from other electronic devices may reduce the range.

Compatibility among Bluetooth enabled devices depends on the version of Bluetooth each is using and also on the profiles and protocols used by both devices (there are a lot of them).

When you activate the Bluetooth application for the first time, you are asked to give a Bluetooth name to your camera. After you have set the Bluetooth

Bluetooth cards can convert a device to a Bluetooth device. Courtesy of Belkin.

application to be active and set its visibility to All, your camera and its name can be seen by other Bluetooth device users.

The camera searches for Bluetooth devices within its range and lists them by a device icon, Bluetooth name, the type, or a short name. You just scroll to the device you want to connect with and select it.

If you use a connection often you can “pair” the devices by using the same passcode for both devices. (Devices that do not have a user interface have a factory set passcode.) Pairing with a device makes device searches easier and faster. When pairing with another device you can specify if that device’s access to yours is authorized or unauthorized. If set to *unauthorized*, every connection request from the device has to be accepted. If set to *authorized* connections between your phone and the device are automatic and can even occur without your knowledge. Use authorized access only for your own devices, for example, your PC, or devices that belong to someone you trust.

- *Infrared* lets you send or receive photos to and from a compatible camera and other device on a beam of light (which you should never point at anyone’s eye). To begin a transfer, point the infrared ports of the sending and receiving devices at each other and be sure there are no obstructions between them. The devices should be within three feet of one another. Once arranged you use the receiving device to activate the infrared port and the sending device to select the desired infrared function and start data transfer.

The Infrared Data Association logo.

IrTran-P (Infrared Transfer Picture) is an image communication standard for digital cameras based on the Infrared Communication Standard specification created by IrDA. IrTran-P service is a listen-only service; it never initiates the IrTran-P connection. To be safe, don’t leave IrTran-P enabled since all incoming files sent over IrTran-P are automatically accepted. Be sure they were sent from a trustworthy source to avoid viruses.

- *Wi-Fi* is the fastest available network technology and can easily transfer even large image files quickly. If your camera supports Wi-Fi you can easily access other devices on your home network and transfer files. When away from home you can locate one of the many Wi-Fi hot spots, called *access points*, that have cropped up in places such as airports, hotels, cafes, and coffee shops.

All of the new and forthcoming home wireless network devices use a standard called 802.11. Because this technology is wireless you have the freedom to roam about the house, or even the yard, and still maintain access to the Internet and other devices on the network including wireless home entertainment devices.

How Photos Are Stored in your Camera and Computer

> **TIP**
>
> How digital image files are named and stored on a storage device are spelled out in the DCF and Exif standards.

When you take pictures, they are stored as files on your camera's storage device following rules spelled out in a variety of standards adopted by camera companies. These standards assure that files and storage devices can be moved among cameras and other digital imaging hardware and software. To work with your image files it helps to understand how drives, folders, and files relate to one another. When someone takes up digital photography without having mastered these few simple concepts, they are immediately lost.

DRIVES

Almost all computers have more than one drive. To tell them apart, they are assigned letters and names, and icons are used to identify their type. For example, the increasingly rare drive into which you can insert a floppy disk is drive A and B. The hard drive the computer looks to for the operating system when you turn it on is drive C. Additional drives vary from computer to computer but often include CD or DVD drives, each with its own identifying letter. When you attach your camera or a card reader to the computer, it too becomes a drive and is assigned a drive letter. On many systems it's recognized automatically, but on others, especially older systems, you have to install drivers that let the computer know its there.

> **TIP**
>
> You will often encounter the terms *directory* and *folder*. When computers were used primarily by professionals, the term *directory* was introduced. As computers became more widespread, the more user-friendly *folder* was substituted. Both terms mean exactly the same thing.

FOLDERS

Folders are used to organize files on a drive. Imagine working in a photo stock agency where you're told to find a photo of Yosemite only to discover that all of the photos the agency ever acquired are stored in unorganized shoe boxes. You have to pick through everything to gather together what you want. Contrast this with an agency that uses file cabinets to store their images. A well-organized file cabinet uses labeled hanging folders to group related images together. For example, there might be a hanging folder labeled *California National Parks*. If a further breakdown is needed, labeled manila folders are inserted into any of the hanging folders—basically, folders within folders. There might be one labelled *Yosemite*. With everything labelled and organized, it's easy to locate and pull out the images you need. The same is true of drives on a computer system. The drive is equivalent to the empty file cabinet. It has plenty of storage space but no organization. The organization you need to find things on the camera's memory device is created by the camera, but on your computer, you have to create it yourself.

When you use operating system tools such as Windows Explorer or My Computer to look at a storage device in the camera or card reader, you will find it is listed like the other drives on your system, but it's named *Removable Disk*. (You can right-click a drive and then click *Rename* to change its name.) The memory card contains one or more folders. The one we care about is automatically created by the camera and named *DCIM* (for *Digital Camera IMages*). If you delete it, the camera will recreate it. The purpose of this folder, called the *image root directory*, is to keep together all of the images you capture with the camera. If you use the same card with other devices, there may also be other folders on the same card holding MP3 music or other files.

As you take pictures, your camera automatically creates and names subfolders under the *DCIM* folder to hold them (like placing manila folders in

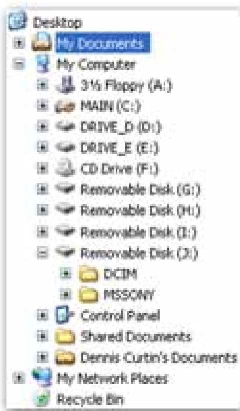
Image files have an 8-character name followed by a period and a 3-character extension.

a hanging folder). The first three characters in a folder's name, called the *directory number*, are numbers between 100 and 999. The next five characters are known as *free characters* and can be any uppercase alphanumeric characters chosen by the camera manufacturer. When a new folder is created, it is given a number one digit higher than the previous directory.

FILENAMES

When an image is saved, the camera assigns it a filename so you can identify it later. Filenames have two parts, an 8-character filename and a 3-character extension. Think of them as first and last names. The name is unique to each file, and the extension, separated from the name by a period, identifies the file's format. For example, a JPG extension means it's a JPEG image file, and TIF means it's a TIFF image file.

Extensions play another important role. An extension can be associated with a program on your system so if you double-click a file, the associated program opens. Also, when you use an application program to open files, it often lists only those files with extensions that it can open. (You can list other file types but is usually requires an additional step or two.) If you change the extension, your system may no longer know what to do with the file.



The first four characters in an image file's name, called *free characters*, can only be uppercase letters A–Z. The last four characters form a number between 0001 and 9999 and are called the *file number*. Canon uses the first four free characters *IMG_* followed by the file number, Nikon uses *DSCN*, and Sony uses *DSC0*. Once transferred to your computer, you can rename images with longer and more descriptive names.

A tree displayed by Windows Explorer indicates drives and folders with icons and labels. The - and + signs indicate if a drive or folder is expanded (-) to show subfolders, or collapsed (+) to hide them.

TREES

One way to illustrate the organization of folders on a drive is to display them as a tree. In this view, all folders branch off from the drive—something like an organization chart. If any of these folders contain subfolders, those subfolders are shown as a second branch from the first. When using a tree, you can expand and collapse the entire tree or any branch. This allows you to alternate between a summary of the computer's contents, and details of each drive or folder.

PATHS

With files stored in folders on a disk, you specify a *path* to get to them. For example, if a file named *IMG_4692.JPG* is in a subfolder named *146CANON* that's in a folder named *DCIM* on drive H, the path to that file is *H:\DCIM\146CANON\IMG_4692.JPG*. The key elements of a path—the drive, folder, subfolder, and filename—are separated by backslashes (\). You might be more familiar with paths from your Web browser that uses a similar approach. For example, the URL...

Here is the path to the file IMG_4692.JPG in subfolder 146CANON that's in the DCIM folder DCIM on drive H. The drive, folder, subfolder, and filename are separated by backslashes.

http://www.shortcourses.com/index.htm

... is a path to a specific page on the Web. Normally you don't type in paths, you click drives or folders to open them. However, many programs display paths on the screen as a navigational aide.

DCF and Exif Standards

The header is an area of the file separated from the image data.

Initially, each camera manufacturer or group of manufacturers took liberties with how images were stored in cameras. As a result it was not always possible to view images captured on one camera on another, or send them to a printer directly from the storage device. Since everyone benefits from compatibility, new standards are constantly being introduced or revised to expand the range of compatibility among cameras, memory devices, printers, and other imaging devices. We still have a ways to go.

The current standard, Design Rule for Camera File system (DCF), is based on JPEG images and other preexisting standards such as Exif (Exchangeable Image File), ExifR98 which specifies rules for files not specified in the Exif standard, and CIFF (Camera Image File Format) that specifies rules for recording, reading, and handling image and related files. Images captured and stored under the rules of this DCF standard can be read by any other camera or other hardware that also supports the standard.

EXIF

FileName: IMG_1000.JPG
FileDateTime: 1000290106
FileSize: 123084
CameraMake: Canon
CameraModel: Canon DIGITAL IXUS
DateTime: 2000:02:15 09:17:56
Height: 480
Width: 640
IsColor: 1
FlashUsed: 0
FocalLength: 8.0mm
35mmFocalLength: 53mm
RawFocalLength: 7.96875
ExposureTime: 0.033 s (1/30)
RawExposureTime: 0.033333335071802
ApertureFNumber: f/ 3.5
RawApertureFNumber: 3.5
FocusDistance: 0.46m
RawFocusDistance: 0.45899999141693
CCDWidth: 5.2323999404907
Orientation: 1
ExifVersion: 0210
Thumbnail

Typical EXIF information

The Exif (Exchangeable Image File) format published by JEITA (Japan Electronics and Information Technology Industries Association), establishes rules for a common format for image files. It specifies image and audio file formats, recommends how folders and files are named, and provides guidelines for how color is managed. ExifR98 is an extension of Exif that extends its compatibility so images captured on one camera can be viewed on another, or output directly to a printer. It defines the range of Exif applications, and sets out detailed rules for recording and playing image files not specified in the Exif format.

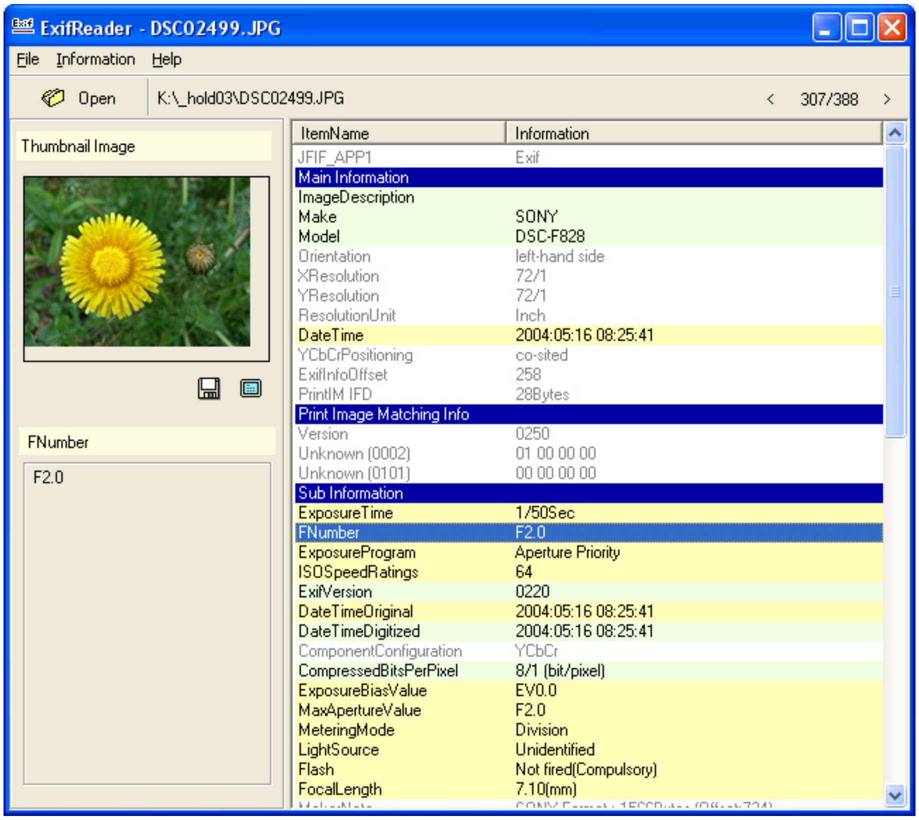
The Exif file format builds on the JPEG file format by specifying how information about an image is stored in the same file. This information, including a thumbnail image, describes the camera settings at the time the picture was taken, and even the image's location if the camera supports an attached GPS unit. This stored information travels along with the image and can be used by other hardware and software programs when displaying or printing the image. Most digital cameras record this information as *tags* (formally called *metadata*) in a JPEG file in an area called the *header*. Newer operating systems and application programs can display this information and even allow you to search for images based on it. Starting with Exif 2.2, information such as contrast, saturation, sharpness, gain control, captured scene type and digital zoom ratio used to capture the image are also saved in the header. This information can be used by some printers to give you better results. Basically, any camera control set to auto at the time the image was taken is free to be manipulated by the printer or other device. Those set to one of the camera's manual choices is considered to be a deliberate choice and not manipulated.

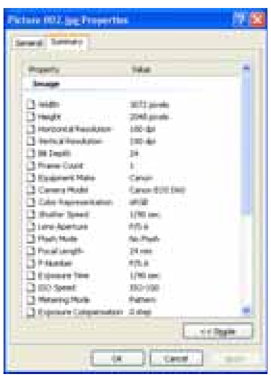
Exif Print

The Exif 2.2 logo.

Exif information can sometimes be lost if you open and then save a file in another file format. (Or even lost when using the camera's own rotate, crop, or other commands that write to the disk.) However, newer cameras and application programs such as Photoshop preserve this important information.

ExifReader is a program that displays the Exif information stored in a JPEG image file.





Windows XP's file dialog box has a Summary tab (top) where you can enter information about an image including keywords. Clicking the Advanced >> button displays Exif tags for the image (bottom).

CIFF

CIFF (Camera Image File Format) Version 1.0 specifies rules for directory and file structures so that a variety of files can be stored and managed efficiently on removable storage devices.

DCF

DCF (Design Rule for Camera File system) defines the entire file system of digital cameras including the naming and organization of folders, file naming methods, characters allowed in file names, and file formats.

DCF was needed because the Exif standard specifies requirements as mandatory, recommended, or optional. This wiggle room left open the possibility of incompatible systems based on the same standard. For example, Exif makes thumbnail recording optional, and provides no rigid standard for their format if they are created. The directory and file naming standards are given in the form of examples, not rules. The DCF standard closes these and other loopholes in the Exif standard to improve playback compatibility.

Although you may never need to know these terms, here are some definitions from the DCF standard that you may run across in manuals, articles, or books.

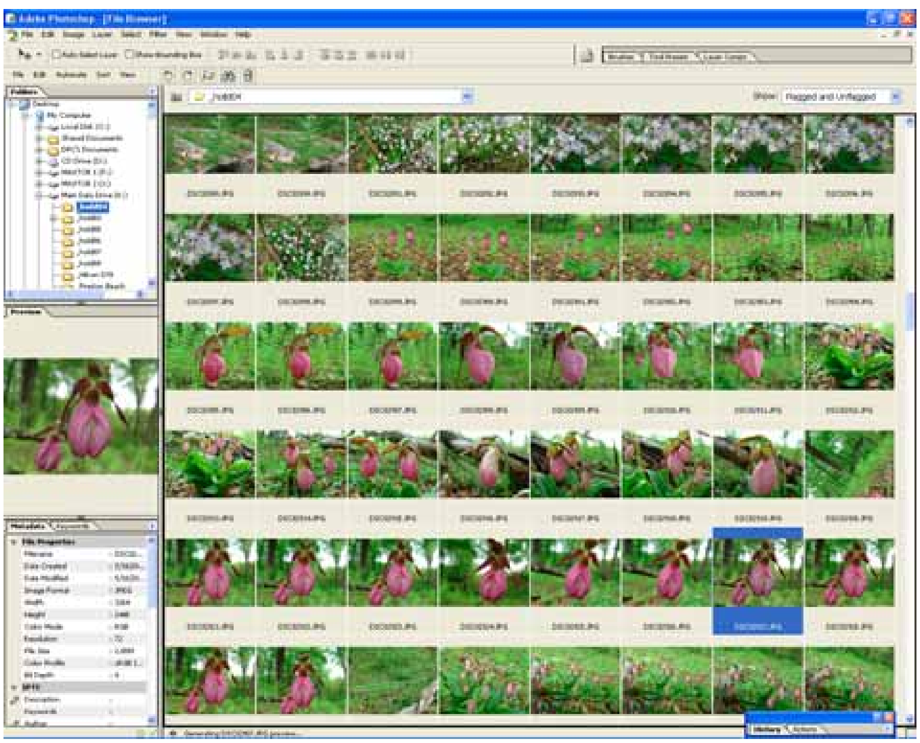
- *DCF basic file* is an image file stored in a DCF folder and having a DCF filename, the extension JPG, and a DCF data structure based on the Exif standard. The compression ratio is not specified.
- *DCF basic main image* is the primary image included in a DCF basic file.

■ *DCF basic thumbnail* is a small version of the main image included in the DCF basic file. The thumbnail image is 160 horizontal pixels by 120 vertical pixels—a size big enough to be recognizable but small enough to be stored easily.

■ *DCF extended image file* is an image file in a DCF folder but having an extension and data structure different from a DCF basic file. Typical examples are TIFF, RAW, and WAV files. DCF does not specify rules for these kinds of files.

■ *DCF thumbnail file* is an optional compressed file storing a thumbnail image of a DCF extended image file. It is stored separately from the image file and has the extension .THM and the same file number as the image it represents. For example, a file named ABCD2222.TIF may be accompanied by a thumbnail image named ABCD2222.THM. Together these two files form a *DCF object*. Although many cameras cannot record or read TIFF images, a DCF thumbnail file accompanying the TIFF image can be read because it has the same format as that used for a DCF basic thumbnail.

■ *DCF object* is a group of related files, called *object components*, that are recorded under DCF rules. DCF defines three kinds of object components: DCF basic files, DCF extended image files, and DCF thumbnail files. However other files such as audio files can be object components. For two or more object components to be combined into an object they must have the same file number although either free characters or extensions can vary so the full names are not identical. An image file ABCD1000.JPG and a sound file ABCD1000.WAV are both object components but are joined into an object because they both have the file number 1000. Actually, all files in a DCF directory with DCF names are DCF object components, even if there is no other object component with the same number. If you protect, delete, move, or copy an object component, all related components in the object are also protected, delete, moved, or copied. The object's components are treated as a single unit.



Photoshop CS includes a File Browser that displays thumbnails and Exif tag information.

Transferring Images to the Computer—Procedures

Two sets of consecutive files selected.

When using Windows to copy or move image files from a storage device to a computer you use the same techniques you use with any other kind of file. Basically you select the files you want to copy or move and then drag and drop them. Windows has a number of techniques you can use to make this fast and easy, but even some experienced users haven't discovered them.

SELECTING FILES AND FOLDERS

The first step is to select the files or folders you want to process using Windows Explorer. When doing so, you may want to display the files as thumbnails so you can see what image each file contains. Many of these procedures work in combination with each other.

- *To select a single file or folder*, click it.
- *To select multiple nonconsecutive files or folders*, click the first file then hold down Ctrl when you click each of the others. The same technique will unselect previously selected images.
- *To select a series of consecutive files or folders*, click the first image in the series and hold down Shift when you click the last.
- *To select more than one set of consecutive files or folders*, click the first image in the first set and hold down Shift when you click the last image in that set. Now, hold down Ctrl to select the first image in the second set, and Ctrl and Shift while you click the last image in that set.
- *To select all files and folders*, click the *Edit* menu to pull it down and click *Select All*.
- *To select all but a few files or folders*, select the few you don't want to select, then pull down the *Edit* menu and click *Invert Selection*.

COPYING VS. MOVING FILES

- If you move files from the camera's storage device, they are first copied to the computer and then deleted from the storage device.
- If you copy files, they are not deleted from the storage device. You either have to do that using your computer or one of the camera's commands that deletes all images.

DRAGGING AND DROPPING

After selecting files or folders, you can drag and drop them onto another drive or folder. Windows Explorer, the best tool for dragging and dropping, has two windows:

- *On the left* is a tree displaying drives and folders.
- *On the right* are details or thumbnails of the files in the folder selected on the tree.

The basic procedure is to drag selected files or folders from the pane on the right and drop them on a drive or folder on the tree. They will be copied or moved into the drive or folder you drop them on. When dragging them into position, ghost images of the files are displayed, and the folder they will be copied or moved to is highlighted. Here are some things to know when dragging and dropping:

- *If you point to a closed drive or folder on the tree*—one with a plus sign (+)—and pause for a moment, the folder will open to display its contents.
- *If you drag against the top or bottom border of the tree*, it will scroll.
- *If you drag and drop files while holding down the left mouse button*, they

HAVOC

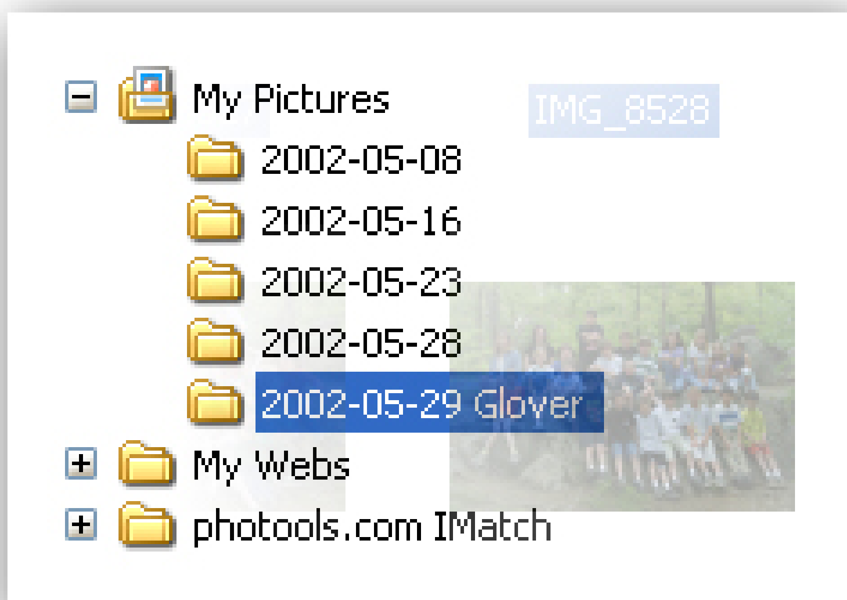
When you connect a camera to a computer or insert a card into a card reader, a number of programs on your system may compete to transfer the files for you. Every software company wants you to use their software so each and every one of them looks for this moment to get an upper hand.

are moved if you drop them on a folder on the same storage device, and copied if you drop them on a folder on another storage device. When you drag them to another device, the pointer displays a plus sign (+) to indicate they will be copied.

- *To choose whether files are moved or copied*, drag and drop them while holding down the right mouse button. When you then drop them, a pop-up menu lets you choose whether they are to be copied or moved.
- *If the mouse pointer displays a circle with a slash through it*, you are pointing at a place where you can't drop.

Almost all digital cameras come with software that will transfer your images for you. This software can be safely ignored if you know how to use your operating system's tools. There are a number of reasons you should do so:

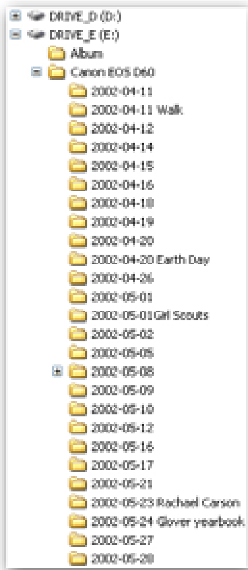
- Operating system tools are on every computer of the same type, anywhere in the world.
- Operating system tools have been more thoroughly tested and proven than programs distributed in much smaller quantities by the camera companies.
- If you change cameras, what you have learned about operating system tools stay useful. What you have learned about camera company software might as well be forgotten.
- Camera company software sometimes has a mind of its own and renames and stores files in a manner you may not choose were you given the choice. Operating system tools let you use your own file management methods.



When you drag files or folders to a folder on the tree they appear as ghost images. The folder they will be copied or moved to is highlighted.

When you hold down the right mouse button when you drag files or folders, this menu pops up when you drop them.

Organizing Your Photo Files



Here is a tree from my system. Because I use so many cameras, I create a folder for each and then subfolders listing the dates I downloaded images. If a folder's images are predominantly of a single subject, I add a short description.

When you move your images from your camera to your computer and then to a CD/DVD disc, you need to do so in an organized way. It doesn't take long to be overrun with images; and all of them with meaningless names to boot. Luckily, with some planning, and the right tools and knowledge, you can work with thousands of images without getting lost.

Before transferring images from your camera to your computer, you should develop a system that let's you quickly find them later. Folders are the heart of any image management system. The best way to organize your images on your computer is to create a folder for images and then subfolders that meaningfully identify the images stored in them. The thing to keep in mind is that your system is not about storing images, but about finding them. Ask yourself, where you'd most likely look for pictures of interest a year from now, long after you've forgotten where you stored them.

There are a variety of ways to organize and name folders, depending on what kind of photos you take or how you use them.

- *A chronological organization* uses folders named with dates in the format yyyy-mm-dd. For example, a folder named 2004–02–10 would contain photos taken or downloaded on February 10, 2004. When using dates, be sure to add zeros to single digit months and days or the folders won't sort into a perfect chronological order. You can use hyphens or underscores between elements, but should avoid using spaces.
- *A subject organization* uses folders named after subjects, events, projects, or experiences. For example, a folder named *Christmas 2003* would contain images of that day. *Emilys Birthday 2003* would contain images of the birthday party.

These two approaches aren't mutually exclusive. For example, if you organize images chronologically, you can add a comment after the date that indicates the subject or project. Alternatively, you can create a chronological system, and then copy the best images to separate subject or project folders. The chronological folders act as an archive of original images, and the subject or project folders become the versions you edit, print, or distribute. This system has the advantage that you never actually edit your original photos. The drawback is that you can have different versions of the same image in a number of different folders. Just be consistent or you'll wonder a year from now if the project folder contains copies or originals.

Once you have developed a system that works for you, you need to decide what folders and files should be copied or moved to CDs or other form of long term storage. In our example, you would always transfer the original chronological folders, but only transfer the subject or project folders if you want to preserve the collection of related images, save editing changes, or distribute the images to others.

The tools you use to create folders, and view, transfer, and manage images include those that come with your computer as part of the operating system, thumbnail browsers, and best of all, image or asset management programs that store thumbnails and descriptions in a database so you can even locate images that are stored on CD/DVDs in a drawer. We'll explore these tools in the pages that follow.

> **TIP**
>
> Shorthand ways of ordering and separating days, months, and years vary from country to country. However, sorting on the computer works best when dates are in the format yyyy-mm-dd.

STORING IMAGES—HARD DRIVES

Maxtor makes a line of inexpensive high-capacity hard disk drives that are ideal for digital photographers. Courtesy of Maxtor.

As your images accumulate, you'll find that storing them can be a problem. However, hard drives have become so inexpensive, and their storage capacity so great, that you can have an almost endless supply of hard disk space on which to store them. Currently, affordable drives have capacities up to 250 Gigabytes—enough room to hold more than 125 thousand 6 megapixel images at 2 Megabytes each. If these were film images at 50-cents a picture, you've have a small box of images worth over $60-thousand dollars! One way to think of this amazing capacity is by how long it would take you to fill a drive. If you shot 100 photos a day, you could shoot for over 3 years before filling a 250 Gigabyte drive. And forget backing these drives up to CDs or DVDs. It would take 53 DVD disks to back up a drive like this and 357 CDs. Even tape backups have fallen far behind.

It used to be simple—hard disks were inside computers and nowhere else. Well, they have escaped from the box and are everywhere—from pocket-sized personal media players that play digital music and even videos to Digital Video Recorders (DVRs) used to record TV and slide shows programs. Since anything that is displayed on the TV screen can be recorded on a hard drive, you can record slide shows fed directly from the camera, over a home entertainment network, or from a CD/DVD burned on your computer. DVRs record with much better picture quality than VCRs, but if there is no way to archive what you've recorded, you'll eventually fill the hard drive and have to start erasing. This is now changing as DVRs drop in price. The ideal DVR has both a hard drive and a DVD recorder so you can use recorded discs to move programming back and forth between your computer and TV.

Mirra makes a device that not only backs up your photos on a hard drive but also lets you share them with others over the Internet.

When comparing hard drives, here are some things to consider:

- *Capacity* ranges up to 250 Gigabytes and since these drives cost only a few hundred dollars why look at anything smaller? In fact why not a second one to use as a backup drive?
- *Internal or external.* There are both internal and external models from which to choose. An external model plugs into a USB or Firewire port and is almost as fast at the hard drive built into your system. The best thing about an external drive is that if you have more than one system, upgrade to a new computer, or visit a client's office, you can just plug your drive into the other computer. On the newest systems you don't even have to install software drivers to have it recognized. On older systems you may have to.
- *Rotational speed*, or how fast the disk spins, is usually between 5400 and 10,000 RPM with faster speeds transferring more data in a given period. Consider that at 10,000 RPM, the outer edge of a 5.25 hard disk is moving at 156 miles per hour and if set loose on edge, it would travel 2.6 miles in a minute.
- *Transfer rate* is the number of bytes per second that the drive can deliver to the CPU.
- *Seek time* is the amount of time, in milliseconds, between when the CPU requests a file and when the first byte of the file is sent to the CPU.
- *Buffer* stores data before it's written to the disk. These are important when feeding a stream of time-dependent data such as video to the disk so data isn't skipped or lost because the drive can't keep up.

Western Digital makes a Media Center hard drive that contains built-in card slots.

Storing Images—On the Road

MAKING COMPARISONS

One tried and true way to select storage devices is by comparing the cost per megabyte/gigabyte of various devices. To calculate this number, divide the price of the device by its storage capacity in megabytes/gigabytes. For example, at the time this book was written a 2 Gigabyte Microdrive was selling for $250 and a 2 Gigabyte CompactFlash card for $450. The two costs per Gigabyte were $125 vs. $225.

When it's time to hit the road with your digital camera, the problems begin. With traditional cameras, you just stuff the bag with film and shoot till it runs out. Then you go buy some more. With digital cameras it isn't that easy (unless your camera stores images on CD/DVD discs). When you take a lot of photos or are on a long trip, you'll eventually reach the point where you have to move images to another storage device. This is especially true when you capture high-resolution images or use file formats such as RAW or TIFF that give you the best image quality but create huge files—15 megabytes and even larger in some cases. When shooting close to home, moving images off a card is fairly easy. You just transfer the images, erase them from the card, and go back to shooting. It's more difficult on long trips. Here the alternatives are few:

- *Find a place to burn CDs for you*. This will now be done by most photo stores but they are often clueless. You put your images at risk.
- *Buy more or larger memory cards*. This is a common solution but it can be expensive if your trip is long or you shoot a lot of large images.
- *Carry a notebook computer*. Not only may you already have one of these, but its large screen and ability to run your choice of application programs lets you have a mobile version of the typical desktop system. However, a notebook computer isn't always the ideal portable device because of its size, weight, short battery life, and long start-up time.
- *Buy a portable storage device*. Increasingly, devices are being introduced that solve the image storage problem on the road. These devices come in a number of forms but generally are either based on a hard drive or a CD-RW drive. You just insert your card into a slot, often using an adapter, insert a CD if your device uses one, and then press a button to begin transferring your images. You can then erase your camera's storage device to make room for new images and resume shooting. When you get back to your permanent setup, you copy or move the images from the portable storage device to the system you use for editing, printing, and distributing them. If the device burns CDs, you can read them in your system's CD drive just like any other CD.

Many portable storage devices also let you view your stored images on the device's LCD monitor or on a connected TV—and even pan, rotate, and zoom the images. Some also let you print directly to a printer without using a computer. The trend is to go even farther and combine digital photos, digital videos, and MP3 music in the same device—sometimes called a *personal media player*. With a device such as this you'll be able to create slide shows with special transitions, pans, and accompanying music and play them back anywhere.

The Epson P-1000 is a portable storage and viewing device with a 10 Gigabyte hard drive and a 3.8 inch screen.

Storing Images—CD Drives and Discs

CD drive. Courtesy of LaCie.

As we mentioned earlier, Sony makes cameras that store images on CDs. Courtesy of Sony.

The Roadstore from Micro Solutions copies image files to CD-R discs without a computer involved. Courtesy of Micro Solutions.

Mitsui Gold CD-R discs are considered one of the best storage CDs because of a real gold added to the reflective layer—others use silver which doesn't have the same archival properties. Courtesy of Diversified Systems Group.

CDs have become a popular way to backup images to protect them, share them with others, and even to store slide shows that can be played back on a computer or DVD equipped TV set. CD drives that can record or *burn* CDs are now standard on almost all computers, but if you don't have one you'll find that many photo stores can transfer your images to a CD for you. In some cases, photo kiosks have CD drives as part of the system. These resources can be especially helpful when traveling.

CDs, like DVDs, are optical storage devices, and the discs on which you store images, are economical. To store your images on a CD, you need a CD-RW drive (*RW* stands for *ReWriteable*), the appropriate recordable discs, and CD recording software. Since the data is recorded on the disc with a laser that heats the surface, the process or recording or writing is often called "*burning*" the disc. *Writing*, *recording*, and *burning* all mean the same thing.

CD discs, similar to the audio CDs so popular in the music recording industry, store up to 700 megabytes of data. Depending on how they are burned, they can store data readable on a computer, MP3 music files readable on many audio devices, and even image files and low-resolution video that can be played back on a late model DVD players. There are two kinds of blank CDs on which you can record:

- *CD-Recordable* (CD-R) discs can be written to once. These disks have a thin layer of silver or gold with a layer of green dye below. To record data, the laser forms bumps in the dye layer. When played back, the computer reads a bump as 1 and the absence of a bump as 0. The fact that you can only write to these discs once isn't really a drawback. Many photographers want archival copies of images and the fact that these discs can't be modified once created is actually a benefit.
- *CD-ReWriteable* (CD-RW) discs can be recorded, erased, and reused, just like a hard disk. These discs (and DVD-ReWriteable discs) record data by using a laser to change a material from a well-structured crystalline state to a less-ordered amorphic state, a process called *phase change*. When a bit is in a crystalline state it reflects more light than a bit in an amorphic state. The drive can read these differences in brightness.

Since many of a CD's characteristics are fixed by specifications that make them compatible with the millions of drives already in place, performance is boosted by spinning them faster in the drive. The faster they spin, the faster you can locate and open images. The spin rate is designated by the 2x, 4x, 6x, and 8x designations each drive carries. For example, a 32x drive spins 32 times faster than the original 1x drives that transferred data at about 150 kilobytes per second. Generally, drives are slower at recording than they are at playback. In specs and on boxes, you'll often see a speed ratings for each task—playback, writing CD-R discs, and writing CD-RW discs.

CD (and DVD) discs are relatively new forms of storage. How long they will last before data is lost isn't yet known with any certainty. Most tests use accelerated aging that may or may not accurately reflect the future. The consensus seems to be that they will last a few decades if manufactured and stored properly. Given the uncertainty, the best thing you can do is buy only name brands and store them in acid-free envelopes in a cool dark place such as a drawer or album. Discs that use a gold, rather than a silver layer, are generally considered to last longer.

Storing Images—DVD Drives and Discs

The CD started it's journey as a way to distribute high-quality music and evolved into a major storage medium for computer programs and data. The newer DVD started its journey as a way to distribute high-quality movies, but has been widely adopted by computer users. (When a DVD device is attached to the TV it's called a *player* or *recorder*. When attached to a computer it's called a *drive* or *writer*.) The widening use of DVDs even required a change in the meaning of the acronym from "Digital Video Disc" to "Digital Versatile Disc."

LaCie makes small FireWire Pocket DVD-RW drives.

There are many notebook computers that have built-in DVD drives, including this ultralight from Sony.

Many computers come with DVD drives that can playback DVDs and even record them. If yours doesn't you can easily add one. It's the recording part (often called *writing* or *burning*) that's important for digital photographers for the following reasons:

- *Storage capacity*. CDs can store, at most, 700 Megabytes of data. In an era of 4 Gigabyte memory cards and 15 megabyte RAW or TIFF image files created by some cameras, 700 Megabytes of storage is looking small indeed. DVDs currently store 4.7 Gigabytes, more that 7 times the capacity of a CD. As two-sided discs become more common, the capacity will climb to 9.4 Gigabytes. Even newer devices based on blue lasers will eventually push these limits to almost 30 Gigabytes and beyond. As a place to store your digital images, DVDs have a great future.
- *Sharing*. DVDs that you burn yourself can also be played back on your TV set using some late model DVD players. You can even burn multiple DVDs and send them to friends and family—an ideal way to share your images.
- *Backward compatibility*. One good thing about moving to a DVD drive is that you don't loose compatibility with the world of CDs. Almost every DVD drive will also read from and record to CD-R and CD-RW discs.

CDs and DVDs are a lot less expensive when you buy them on spindles. You then use envelopes to store them in drawers.

COMPATIBILITY ISSUES

Although the reasons for getting a DVD drive are persuasive, buying one can be confusing. There are ways to go wrong. The big problem we face is summed up in the word "compatibility" defined by the dictionary as “existing or living together in harmony." There are two competing formats and they are not compatible. Discs created on one type of drive can't be read on the other. The two competing formats are known as the + (plus) and - (dash) formats and each is supported by its own group of companies.

- The plus (+) group, called the DVD+RW Alliance (www.dvdrw.com), supports DVD+R (for discs you can write to once) and DVD+RW (for discs you can erase and reuse).

Sony Electronics makes Dual RW DVD drives that supports all of the popular formats including DVD-R/-RW, DVD+R/+RW, and also CD-R/CD-RW.

DVD±RW

DVD drives that work with multiple formats often have a +/- symbol or super multi label.

Sony makes a DVD Handycam® Camcorder that records on 1.4 Gigabyte DVD discs that play in most current DVD players and drives. Can DVD still cameras be far behind?

A DVD-Ram cartridge.

Duplicators let you duplicate all kinds of DVDs. Courtesy of LaCie.

- The dash (-) group, called the DVD Forum (www.dvdforum.org), supports DVD-R (for discs you can write to once) and DVD-RW (for discs you can reuse).

When buying a new computer you'll find that some large companies support one format or the other—but not both. A temporary solution to this problem is a multiformat or dual DVD drive that reads and writes DVD-R/W and DVD+R/W (If it just reads DVD discs it's called a DVD ROM.)

When buying DVD discs, be sure they match your drive. For example, if you have a plus (+) drive, buy only DVD+R or DVD+RW discs. You'll find that there are standard discs and much more expensive "authoring" discs used when you are creating a master discs that will then be mass produced. DVD-R and DVD+R discs tend to be more compatible with DVD players attached to the TV than the rewriteable (RW) formats.

CHOOSING A DVD DRIVE

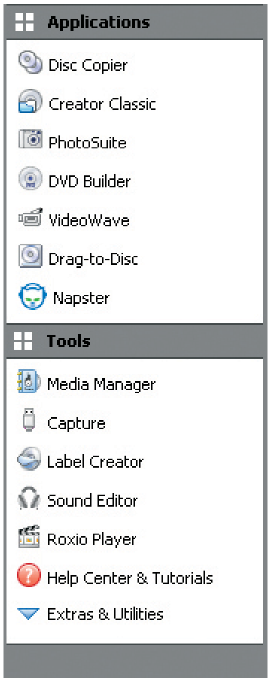
Here are some questions to ask about any DVD drive you are considering:

- *Format*. Dash, plus, or dual format—sometimes called a super-multi drive?
- *Speed* is indicated with numbers such as 4x, 12x, 16x and so on. Generally there is a separate rating for recording (writing) and reading each format. For CDs, 1x means you can record 150 kilobytes per second, but for DVDs 1x means 1.3 megabytes per second. Since the base rate of a DVD is about 9 times faster than a CD so it's hard to compare the speed of the two without doing a little math. However, a DVD that can record at 4x is about as fast as a CD that can record at 36x (4 x 9).
- *External or internal model*? External drives connect to your computer using a fast FireWire or USB connection. If your computer doesn't have one of these ports, you can add them by installing an inexpensive card from a company such as Adaptec (www.adaptec.com) or Belkin (www.belkin.com). To add an internal drive you have to open the case to mount and connect it.
- *Software*. Does the software you need to record DVD discs come with the drive?
- *Standards*? Because there are two major video broadcast standards in use around the world (PAL and NTSC), don't count on your DVD slide show being playable in another country unless you can burn the disc in the right format.
- *If it is part of a DVR will it play DVDs burned on your own computer's DVD drive*? If you exchange discs with others will it also play those discs?
- *Does it have a slot for memory cards* so it can display images you've just taken?

HERE WE GO AGAIN

New high capacity DVD discs are being developed in at least two competing formats (surprised?)—HD-DVD and Blu-ray. Newly developed blue lasers have a shorter wavelength than the current red lasers and hence a thinner light beam that can read and write smaller bits of information on a disc.

CD/DVD Burning Software



Roxio is representative of the trend to combine a lot of separate utilities into an integrated program. The illustration above shows the Windows menu for both applications and tasks.

To copy files to a CD or DVD, you need recording—sometimes called *authoring* or *burning*—software. This software is readily available—for example, the latest Windows and Mac operating systems let you burn a CD or DVD directly from the operating system. In addition, most drives come with software, often a somewhat limited version of a more powerful stand-alone program or suite of programs that you have to pay for. But you can also buy software that offer more features. Stand alone CD/DVD burning software is disappearing as it becomes just one more function on a long list of features used to edit, organize, and distribute video, photo, and audio shows.

The features of these programs vary, but usually include the ability to burn a variety of files including music MP3s, photos, and videos. Some include backup software to manage backing up your system. You can also use some to create slide shows and videos to share with others. Depending on how you burn discs, they can be played on the computer, CD players, and even late model DVD players connected to the TV.

There are two ways to burn discs—incrementally (multisession) or all at once.

- *Incremental* (called *track-at-once* or multisession) recording lets you save, copy, move, or even drag and drop files to a CD/DVD disc. In effect the CD/DVD acts just like other drives on your system. To access the files, the session must be finalized, but you can still add more files to the disc later in other sessions. Once you finalize the disc, you can't add additional files. (One problem is that some entertainment system components can only recognize the first session.)
- *All at once recording* called *disc-at-once* recording burns the files to the CD/DVD and then finalizes both the session and the disc so no further files can be added.

If you exceed the capacity of a single disk, some programs can "span" disks and prompt you when one disc is full, to insert another. When you want to make copies of your shows, you'll find that many burning programs also have a disk duplicating command that you use when you want a copy of an existing disc, even if your system has only one drive. When your quantities get high enough, you need a disc duplicator to create copies from the master disc. There are desktop units you can purchase (they aren't inexpensive) or you can use an outside service. These units recognize the type of disc you are asking it to copy (audio, data, etc) and then makes an exact duplicate. If you are burning discs for wide distribution you either need a printer that prints on discs with a printable surface, or pay someone else to do the labeling for you.

Roxio's DVD Builder is the application used to burn SVCDs and DVDs.

LABELING CD/DVD DISCS

Lumocolor pens from Staedtler are permanent markers designed to write on the shiny surface of DVDs and CDs. Courtesy of Staedtler.

When you burn a disc, your software lets you add a short title that will be displayed by your computer when you access the disc in a drive on your system. The name will also be used by image management software to keep track of your images. If you don't specify a name, the software will automatically generate one using the current date and time.

Although a disc is labeled electronically when burned, you also need to physically label it. Generally, the information should be on the disc itself, not on an envelope or insert. It's too easy for these to get separated from the disc. One way to label a disc is with a permanent marker pen that writes on the non-recording side of the disc with ink that won't rub off with use. For longevity reasons, the best choice is a pen such as the Dixon RediSharp Plus! that uses water-based inks. Some of these marker pens, such as the Sharpie use solvent-based inks and should be avoided. You can identify one from its solvent odor. Solvents can attack the protective covering of the disc, even when you write just on the label side. Over a long period of time, possibly measured in decades, this can affect the data.

Some Epson printers print directly onto the surface of inkjet printable CD/DVD discs.

For a more professional look, you can buy press-on CD/DVD labels that you print and stick onto the surface of the disc. One major problem is alignment because once the label sticks, it's stuck. Unlike life, there are no second chances. To help you get it right the first time there are alignment gadgets that center the label as you press it onto the CD. When using these labels, apply them after recording the disc. If you apply one first and it's slightly off-center, it may affect the recording process.

Most CD/DVD burning programs include software you use to lay out and print labels and even jewel case inserts. There are also kits available. The software usually has a number of backgrounds from which to choose (or lets you use your own photos as backgrounds), and text boxes into which you type your text. You don't have to be technically proficient or very artistic to get a good design.

Neato makes an applicator that centers the label and the disc to the label goes on right the first time. Courtesy of Neato.

Should you ever decide to ramp up your CD/DVD distribution efforts, the next step is a label printer. These printers print on special disks that have a water permeable coating on one side. If it doesn't have this special layer, the ink will bead up on the surface of the disc and flake off when dry. Inkjet printable discs are produced by several major companies including Imation, Maxell, Memorex, Mitsui, TDK and Verbatim and can be purchased from office supply and on-line retailers. A number of photo printers from Epson have added the ability to print labels directly onto these printable disks. If the market supports this feature, it will become more common. These printers include software that you use to design and print your labels. When ready to print, you place the inkjet printable CD or DVD into a tray that protects it as the tray passes through the printer's straight-through paper path. There are also printers designed for the sole task of printing labels on discs and there are even robots available that will insert one disc after another into the printer.

Avery and others make die cut pages on which you print disk labels and jewel case inserts. Courtesy of ezlabel.com.

If you ever do large quantities of a single disk, you may want to have them professionally duplicated and the labels silk-screened. You can also give your own discs a professional and personal appearance. Just have a supply of blank discs silk screened with professional graphics, leaving a space to write in specific information such as the discs's name or title.

Image Management

If you've set up your folders systematically, it's not hard to locate images taken on a certain date or during a certain period. However, you need to see the actual images to choose the specific ones that interest you. You can do so with any program that displays your images as small thumbnails. Viewing thumbnails is so important this feature has been integrated into operating systems and almost every digital camera and photography program.

Windows XP has a filmstrip view that lets you look at thumbnails, with the currently selected one enlarged.

THUMBNAIL VIEWERS

The days of the stand-alone thumbnail viewer are over, or at least numbered except in small devices such as cameras, PDAs and cell phones. The ideal thumbnail viewer lets you quickly scan a large grouping of photos and quickly enlarge any so you can better evaluate the images. Some programs have a slider bar that zooms the images larger and smaller. Others have a preview type of command that enlarges an image to fill the screen. Windows XP has a filmstrip command that runs the small thumbnails along the bottom of the screen and above it displays an enlarged version of the currently selected thumbnail. As with all programs, features get added over time. Many thumbnail programs also let you transfer images, look at selected images as a slide show, rotate images, perform minor editing, and generate indexes or even gallery pages in HTML format.

The distinguishing feature of a thumbnail viewer is that it doesn't permanently store information about an image or it's thumbnail. Each time you open a folder, the thumbnails must be generated from large image files all over again. (Some viewers temporarily store the most recently generated thumbnails in an area of memory called a *cache*.) This can take some time, especially when there are a lot of images or the computer is an older model. Permanently storing information and thumbnails is left to a more advanced kind of program called an image or asset manager that uses a database.

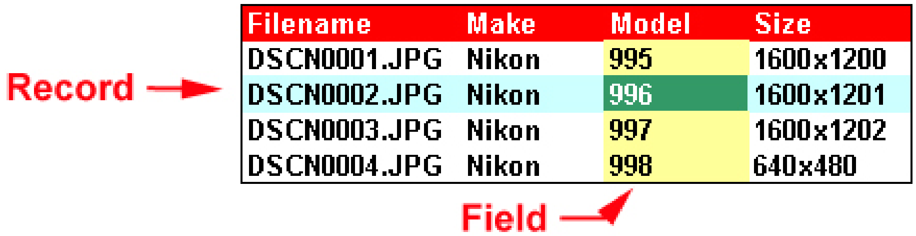
TIP

■ A thumbnail image is actually created at the time you take a picture. In a JPEG image it is stored in the image file and goes anywhere it goes.

IMAGE OR ASSET MANAGERS

Image management programs not only let you view thumbnail images and information about the images, they permanently store this information in a database. What is a database? In one respect it's just a collection of plain old facts. You interact with databases every day without even knowing it. For example, when you use a Web site such as Google to search for the phrase "digital cameras," you are searching Google's database for Web pages in which that phrase appears. In a database, data (facts) are stored in a very structured way using tables with rows and columns much like a spreadsheet.

In a digital image database there is one row or *record* for each image or other file being cataloged. Each record contains a number of columns or *fields* that contain specific facts about the image. Typical fields might be the date the picture was taken, the camera used to take it, the size of the image in pixels, and the name of the file. The record for each image has the same fields, and this is what makes the database so powerful. You can sort the table based on the contents of any field. For example, you can sort it by the date pictures were taken, by their size, or format. You can also search the database by specifying what field to search in and what fact to find. Any images that contain the specified facts in the specified fields are listed. Databases also let you view the information in different ways. You can have it display just thumbnails; or thumbnails, filenames, and image sizes. Another view might be just the EXIF tag information so you can see what shutter speeds or lens focal lengths were used for each image.



A database contains records on rows and fields in columns.

TIP

■ When you burn a CD/DVD, you can add a title to the disc. This title is important because it identifies the disk when you look at it with operating system tools or an image management program. If you double-click the thumbnail of an image that isn't currently on the system, you are prompted to insert the disc. It's much nicer to be prompted to insert *Florida Trip Disc 1*, then to insert disc *050412_0849*.

■ If you don't add your own title to a CD/DVD when burning it, a number will be assigned based on the current date and time. For example, the number *050412_0849* indicates the disc was burned on May 12, 2005 at 8:49 AM.

Many of these programs also index and catalog other files such as movies, sounds, and the like. For this reason, these programs are called by the more inclusive name *asset managers*—each file on your system from a Quark document to a digital image being an asset.

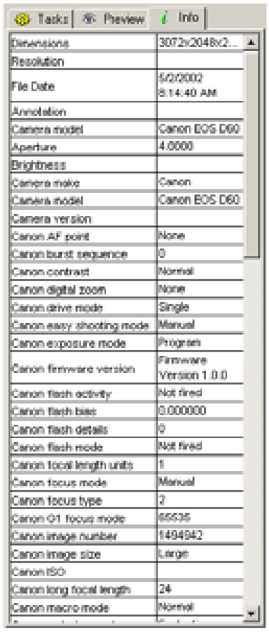
Database-backed asset managers are used to manage small and large collections of images. They have all of the features found in operating system tools and thumbnail browsers, but excel in three ways.

■ *Speed*. Since it takes time for the computer to extract a thumbnail image from an image file, you often have to wait a long time to see what's in a folder. With other viewers, you experience this delay each time you return to the same folder. With a database, copies of the thumbnails are extracted from the full-size images and stored separately in the database so the next time you look at the folder, they instantly pop up on the screen.

■ *Comprehensiveness*. System tools and thumbnail browsers can only display thumbnails and other information of an image that is still on the system. With an asset management program, you can view thumbnails of still images or first frames of movies once they have been added to the database, whether they are still on the system or not. This is because you are actually viewing thumbnails and EXIF tags that are copied from the image and stored in the database. Each thumbnail is linked to its full-size image or points to it. If you open the asset manager and double-click a thumbnail of an image that's still on the system, the image opens full-size. If you double-click an image that is on a CD/DVD in a drawer, the program gives you the name of the disc to insert. Once you have a collection of removable disks, this really speeds things up. Imagine looking through 20 or more CD/DVDs for an image, with a viewer slowly generating thumbnails each time you change discs! It's boring and time consuming.

■ *Flexibility*. Some image management programs let you assign pictures anywhere on your system to logical categories or virtual albums. The same image can appear in any number of such categories even though there is only one full-size copy of the image on the system. When you assign an image to a category, the program just copies its thumbnail and adds a link to the full-size image. For example, an image of a summer meadow may appear in both a "wildflowers" and "ecosystems" category.

You can have one database for all of your disks, or create smaller databases for each disk and store them on the disk along with the images. The only real problem with one of these programs is that a database containing thumbnails and other information about all of your images grows larger and larger over the passing months.



EXIF info displayed from a ThumbsPlus database. Courtesy of Cerious Software.

ANNOTATING AND FINDING IMAGES

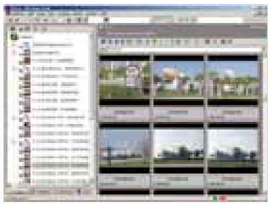
One way to make it easier to locate images later is to add comments or keywords to them. Other information you might use to locate files is automatically stored by the camera at the time the image is taken. The more information you have, the easier it will be to find an image later.

■ *EXIF* (Exchangeable Image File Format) is a specification that spells out how information about a JPEG image is stored in the same file as the image. This information, including a thumbnail image, describes the camera settings at the time the picture was taken, and even the image's location if the camera supports an attached GPS unit. Digital cameras record this information as *tags* (formally called *metadata*) in an area of the file called the *header*. Newer operating systems and application programs can display this information and even allow you to add comments and search for images based on the information in the file. Starting with EXIF 2.2, information such as contrast, saturation, sharpness, gain control, captured scene type and digital zoom ratio used to capture the image are also saved in the header. This information isn't just for managing images, it can also be used by some printers to give you better results. Basically, any camera control set to auto at the time the image was taken is free to be manipulated by the printer or other device to improve results. Those set to one of the camera's manual choices is considered to be a deliberate choice and not manipulated.

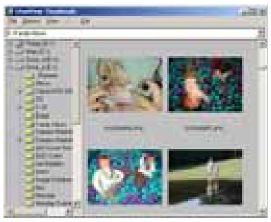
Tags can sometimes be lost if the file is opened and then saved in another file format. (Or even lost when using the camera's own rotate, crop, or other commands that write to the disk.) However, new programs that preserve this information are increasingly common, although they are by no means universal.

■ *IPTC*. When you use an image or asset management program to manage images, you can add information to each image such as key words, copyright notice, caption, and the like. The problem is that when you send the image to someone else, that information is not sent along because it's stored on your computer in the database and is not part of the image file as EXIF tags are. To solve this problem, the International Press Telecommunications Council (IPTC) defines a format for exchanging such information in news content including photographs. Programs that support this standard let you add, edit, and view this information that's attached to the file just as EXIF tags are.

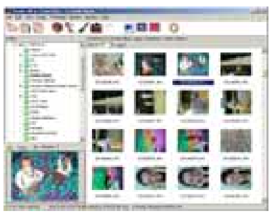
■ *DiMAGE Messenger*. Although digital cameras store information about the settings used to take a picture, and other programs let you attach captions, Minolta's DiMAGE Messenger lets you connect descriptive text to specific portions of digital images, share the combination with others via e-mail or printed copy, and invite related comments to be added by the recipient. To add a comment you use the mouse to drag a box of any size or shape on the image and type text describing that portion of the photo in the window below. These annotated images can be sent to others via e-mail from within the application by selecting the "mail" button from the command program's menu. Since the format is proprietary, the viewer needs a reader which you can send automatically. The reader allow the viewer to open and read images and comments, but it does not allow additional comments to be added or edited. To do that requires a full version of the program. Messenger is a great way to identify individuals in group shots, communicate with designers and consultants, and document technical devices or real estate and insurance appraisals.



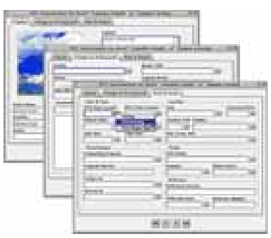
iMatch from PhoTools.



Irfanview.



ThumbsPlus by Cerious Software.



Cumulus from Canto.

PortFolio from Extensis.

CHOOSING IMAGE MANAGEMENT TOOLS

When choosing your image management tools, you need a checklist to help you find the program that offers the features you want. There is a belief among software publishers that more is better. As a result, programs get stuffed with more and more features and programs become bloated and hard to learn. When choosing image management tools, you may not want or need everything, so often "less is more." Keep this in mind when looking for tools to use. In fact, you may look for a combination of tools. One or more fast and easy to learn programs for specific tasks, and another Swiss-army type program that has a feature for every need.

One thing to keep in mind is that it requires a big investment in time, not only to learn the program but also to scan the system for images to store in the database. This is definitely not one of those areas where you want to try a lot of different software. Read lots of reviews before you make your decision.

When selecting your tools, here are some of the widely available features you might want to consider:

BASIC FEATURES

- Supports the file types you work with
- Displays thumbnails
- Displays EXIF and IPTC tags
- Rotates thumbnails
- Displays slide shows
- Zooms and pans images
- Sorts and searches for images
- Creates contact sheets

SEARCH FEATURES

- Locates photos that "look" like one you specify
- Locates duplicate files
- Searches or edits EXIF tags
- Searches or edits IPTC tags
- Uses a database to store thumbnails and other information

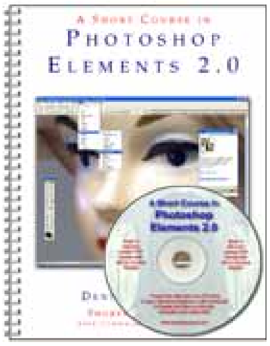
EDITING FEATURES

- Resizes images
- Converts image file formats
- Removes red-eye
- Performs batch conversions or other processes
- Crops images
- Adjusts color and contrast
- Preserves EXIF tags and other metadata
- Sharpens images

DISTRIBUTION FEATURES

- Creates HTML index or even gallery pages using thumbnails linked to larger images
- Includes FTP support to upload images to the Web
- Sends images as e-mails
- Posts images to photo printing/sharing sites
- Makes selected photo wallpaper on your Windows screen
- Burns CD/DVDs with that can be viewed on other computers or on the TV
- Adds slide show transitions and special effects
- Creates albums

Photo-editing Tools



I like Photoshop Elements so much I've written a book about it. It's available at www.shortcourses.com

No book on sharing and displaying prints can possibly ignore photo-editing software. It's rare that an image from a digital camera doesn't need some tweaking and that's what these programs are for. The photo-editing area is highly competitive and there are programs at all levels to choose from. In fact, many of the most useful features are integrated into other programs including those used to desktop publish, create slide shows, or order prints on-line. This helps when you are working on a project and need to do minor corrections to some of the images.

When it comes to photo-editing, there is a 500 pound gorilla in the room named Photoshop. It is just about the only program used by serious professionals. The problem is that it's expensive and takes a lot of time to learn. To reach the much larger serious amateur market, Adobe introduced a much less expensive, but almost as professional version called Photoshop Elements, although it takes effort to master. Elements is a direct adaptation of Photoshop, so everything you learn can be transferred to the more extensive program should you ever decide to migrate to it.

When selecting a photo-editing program, you should be able to use many, if not all, of the following procedures and tools to get the best possible images. Some programs also let you use these same commands on a number of files at the same time—called *batch processing*.

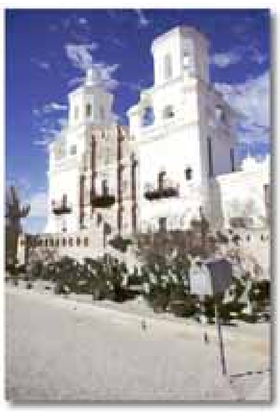
- *Resizing* can be done in two ways, by changing the number of pixels in the image, called its *pixel dimensions*, through a procedure called *resampling*. This process adds or deletes pixels to make the image larger or smaller. You might want to do this to reduce the size of images you will be sending by e-mail or posting on the Web. You might also want to increase the size of the image when making large prints. You can also change the size of the image without changing the number of pixels it contains, called its *document size*. You normally do this when making a print or exporting an image to another application.
- *Cropping* removes distracting or unimportant parts of an image. You might also want to crop if the image has to fit into a specific design such as a newsletter or greeting card.
- *Rotating* an image may be necessary if you turned the camera vertically to capture a picture, or if the horizon line is tilted.
- *Adjusting the tonal range*. Dynamic range in music is the range between the faintest and loudest sounds that can be reproduced without distortion. In photography the dynamic range, also called the *tonal range* or contrast, indicates the range of brightness in an image between pure white and pure black. There are two ways to evaluate the tonal range of an image—visually or graphically using curves or histograms. You should use both approaches because they are not mutually exclusive. Visually, images that use the full tonal range look rich, with smooth transitions in tones. Those that don't use the full range lack contrast, often looking flat and dull. Details may be missing in highlight and shadow areas or the image may be too dark or light.
- *Sharpening*. The apparent sharpness of an image depends a great deal on how much contrast there is along edges and lines. If an image looks soft, it can often be improved by sharpening. Many photographers sharpen almost every image, ignoring this aspect only for images that are deliberately soft

When editing your photographs there are times when you have to select areas of an image or even paint with color. It's hard to make painting strokes with a mouse. That is what accounts for the success of the Wacom line of tablets. The latest, called the CinTiq, even allows you to draw on a small screen displaying the actual image.

A filter has been used to alter the image.

such as fog scenes. You'll find that this procedure, done with an *unsharp mask filter* can make a tremendous difference in photos that you print or post on the Web.

- *Contrast and brightness*. In a darkroom, you control brightness in a print by changing exposure times and contrast by your selection of papers or filters. In digital photography these are usually controlled by dragging slider bars.
- *Color casts* (or hue balance) can be removed so that white or neutral gray areas don't have a color tint.
- *Saturation* refers to the intensity of a color. You can adjust all colors together or select just red, green, or blue for adjustment.
- *Format conversion*. Many programs let you open a file in one format and save it in another. The formats that programs read and write vary but always include JPEG.
- *Touch ups*. Many images have small imperfections that can be retouched if the program provides the tools. A portrait subject might have a small blemish that will be the size of a baseball if you enlarge the image. There may be reflections, or even telephone wires you want to remove. Small areas may benefit by being made a little lighter or darker than their surroundings. Portrait subjects may have red-eye caused by flash in a dark room.
- *Thumbnail view* lets you see images so you know which to open.
- *Contact sheets* let you evaluate a number of images. Some programs will automatically lay out contact sheet pages and let you specify what information to print on them along with each thumbnail.
- *Selecting*. When editing a digital photo, many commands work on the entire image. However, if you first select an area of the image, you can edit just that area without affecting other areas. You can also copy, move, or delete selected areas, perhaps to create a collage or remove a background.



A watercolor filter makes the photo look like a painting.

The background of the monster has been selected and removed (top left), a new photo opened (middle) and then the monster copied in (bottom right) to create a composite image.

The background of the original image (left) has been selected and removed (right).

Filters or actions can add edge effects, mats, and frames to your images. The software you use for these effects comes as a plug-in to your photo-editing program or as a stand-alone program. Courtesy of Human Software.

You can also cut out the selected part of one photo and paste it into another. Creating these composite images is one of the most entertaining aspects of digital photography.

■ *Adding text* to images is usually the realm of graphic designers, more so than photographers. However, you should be able to so to create title slides for your slide shows, add copyright notices to your images, or just invent ways to combine text and images in creative ways.

■ *Layers* let you edit images by overlaying changes on the original image. You add layers as you edit and if you then hide or delete the layers, the image reverts to its original form. Before layers were introduced, changes were always made to the original image and were difficult or impossible to undo later. Every change had to be well planned, as if you were carving in stone. Now you can use layers to make changes and modify and delete them at will without affecting the original image. The more you learn about layers, and the tools you use to manage them, the more uses you will find for them—even using them to create animations.

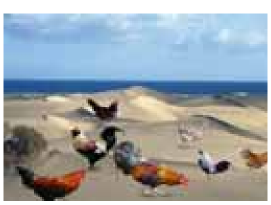
Photo/Graphic Edges lets you do amazing things with the edges of your photos. Courtesy of Auto F/X.

■ *Filters*. When many people first get their hands on a photo-editing program, they quickly discover filters. Since one of the most interesting things to do with digital images is to manipulate or modify them in some way, filters are a great place to start. Many, such as the unsharp filter are used to make your images look more like the original scene. However, many others can make photos look like paintings, stained glass windows, or other objects. You can emboss images, twist and twirl them, add textures, and create all kinds of creative havoc. Filters are easy to use, you just select one and sit back and watch your computer go to work. If you don't like the result, just use the program's undo command. And don't stop with just one filter, use two or more in succession on the same image and watch as it moves further and further from reality. You can always just abandon the file without saving it.

Because Photoshop is so widely used, it stands to reason that it, and it's sibling Photoshop Elements, would have the most filters. Many of these are built-in, but you can also purchase separate *plug-ins* to expand your library of filters from which to choose.

■ *Actions*. Adobe lets you automate tasks by grouping a series of commands into a single command. Photoshop calls these *actions* but they are similar to macros in other programs.

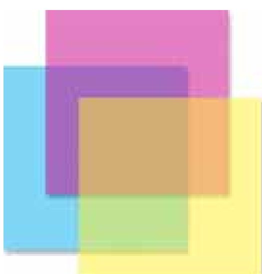
Here a Fred Miranda action was used to add a simulated mat and frame to an image of a butterfly.



PhotoSpray lets you select birds flowers or other natural objects and paint them on your images. Courtesy of Human Software.

Color Management

One thing that's often overlooked is a consistent viewing area. Color experts recommend a neutral colored room with diffuse fluorescent lighting with complete spectrum tubes and ideally egg-crate lighting diffusers. If you don't have the money for a new room, a color viewing booth is a less expensive alternative. Courtesy of Just-Normlicht.



CMYK uses cyan, magenta, yellow (and black) to form all other colors.

The CIELAB color model courtesy of Billy Vriggs at Scanline (http://scanline.ca.

As you prepare your images to be displayed and shared, you move them through a series of steps, called a *workflow*. As you do so, colors rarely remain predictable and consistent. The original scene captured by the camera doesn't look the same as the image on the monitor, and the printout is different from both the original scene and the screen version. When you then share images with friends, they look different on their screens or printouts. There are reasons why this is so.

■ *Different color models*. An image displayed on the monitor uses a *color model* (also called a *color space*) called RGB and printers use one called CMYK. The RGB model creates an image with transmitted Red, Green, and Blue light and the CMYK model creates it with light reflected from Cyan, Magenta, Yellow, and Black inks. There is no way the two images can ever be identical because the technologies are so different.

■ *Different color gamuts*. The range of colors that a device can display or print, called its *color gamut*, varies from device to device. To see this for yourself, visit an electronics super store and look at the walls of TV sets, all with slightly different colors. If you distribute your images on a DVD, they will vary just as widely when your friends display them on their computer or TV screen.

Color management systems (CMS) are designed to help you cope with these fundamental problems by keeping the colors in your images as consistent and predictable as possible as they pass through the various stages of the workflow. Although you can't control other peoples display devices (or even many of your own, such as the TV) you can ensure that your images are as close to perfect as they can be. To accomplish this, a color management system performs three main functions:

■ *Adjusts colors* between devices that have different gamuts, or other variations or limitations, so the colors remain consistent.

■ *Converts colors* from one color model to another, for example, from RGB to CMYK.

A color management system works by analyzing an image and assigning each pixel a *color value*. To do this, it refers to a color model based on the way we see colors. In most cases this is a color model called *CIELAB* (pronounced "see-lab"). Since this color model is based on the way we perceive colors and not based on any particular device it is called "device-independent" and contains almost all of the colors a human can perceive. Other color spaces used in photography such as RGB and CMYK are smaller because they are limited by what devices are physically able to display or print. When any color found in one of these device-dependent color models is looked for in CIELAB, the color will be found there because CIELAB contains so many colors. (Interestingly, the actual CIELAB color model can't be accurately printed or displayed because no device has all of the required colors.)

Once the color management system has matched all of the colors in an image to the CIELAB model, it "knows" what the image "should" look like. Its next step is to determine what your monitor or printer is capable of and overcome its limitations to reproduce the image as accurately as possible. To do this it might have to adjust each pixel's brightness, hue, or saturation. If a color in the image can't be reproduced by the device (called *out of gamut*), the color

TIPS

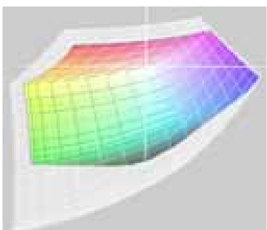
Profiles are not permanent. They need to be redone periodically because hardware colors drift as a device ages. They also need to be redone if any settings or parts are changed.

management system has to reassign it to the closest color the device can display or print.

How does a color management system know what your monitor and printer are capable of? It's by looking at a profile that is essentially a translation table. The profile shows how your screen and printer differ from the ideal CIELAB model. The color management system uses the profile to make all of the adjustments needed to make the display or print as accurate as possible. For example, it might make a particular red in the image darker so it appears the same on the screen as it will in the print. There are three kinds of device profiles:

- *Input profiles* for devices such as scanners and digital cameras. To profile a scanner, a target with color patches (either a print or slide) is scanned and the computer than compares the scanned values with the known values of the target. The differences and similarities in those two sets of values is used to create a profile for the scanner. A digital camera can be profiled the same way, with just the first step being different. Instead of scanning the target, you photograph it under the recommended lighting. To be accurate you need to create a profile for each lighting situation in which you photograph.

- *Display profiles* for devices such as CRT monitors and LCD flat panel displays. To profile a monitor, you attach a color measuring device called a *spectrophotometer or colorimeter* to the display screen. Profiling software running on the computer displays a number of known colors while the device reads the colors' values. Profiling software compares the known and measured results and creates a profile that automatically adjusts the monitor or video card to accurately display the colors. Some programs let you create a visual monitor profile without using a color measuring device. This software walks you through steps where you adjust brightness, contrast, and color balance as you create the profile step by step. Although not as accurate as a profile done with an instrument, it's better than nothing.



The sRGB color space shown here in color, has a much smaller gamut than the Adobe RGB color space shown here in white.

Sony's Artisan Color Reference System has integrated profiling hardware and software.

ColorVision's Spyder calibrates your monitor at an affordable price.

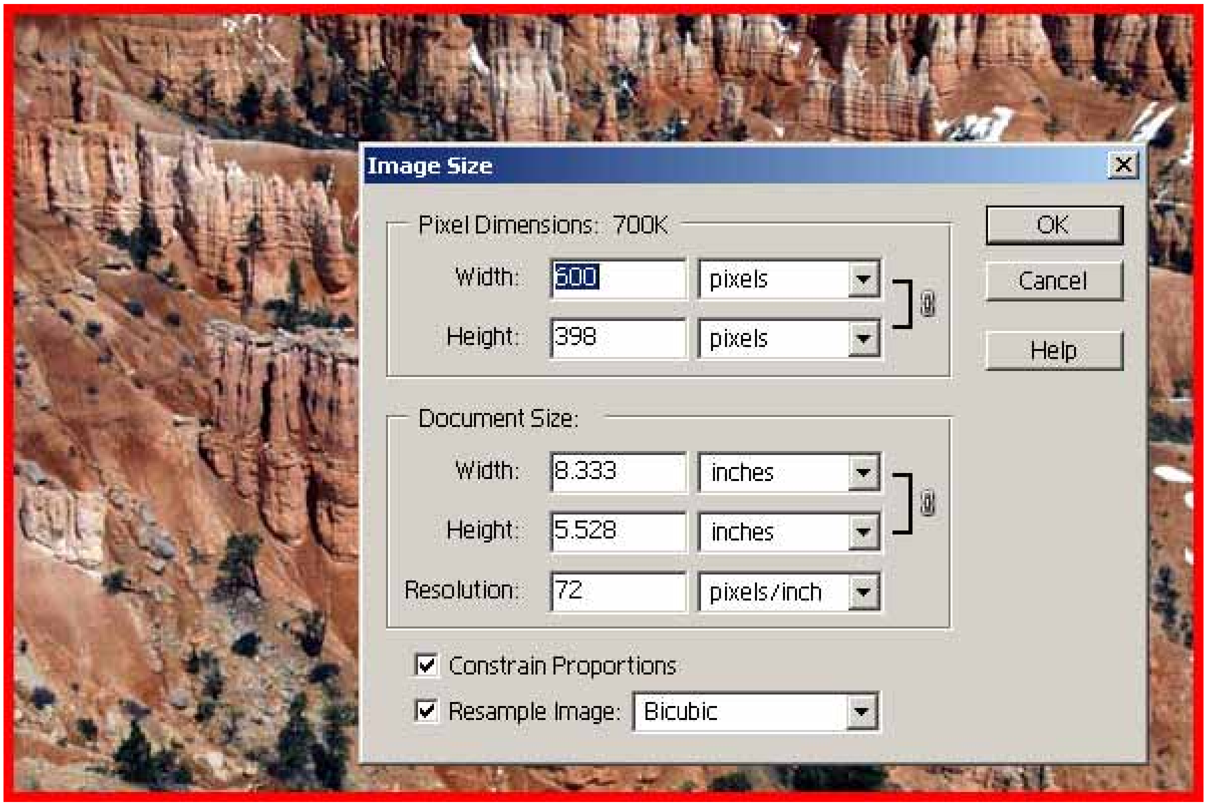
- *Output profiles* for devices such as printers, copiers, film recorders, and printing presses. To profile a printer, you open an image of a color chart and print it out. You then use a *spectrophotometer* to read each color patch in the printout. Profiling software compares the known and printed values for each patch and creates a profile. When you buy a printer, it contains a number of *generic profiles* created by the manufacturer. You see them when you specify what kind of paper you are printing on. The paper type your select; glossy, matt, and so on, determines what profile the printer uses. In fact one problem with profiling printers yourself is that you have to do so for every ink paper combination you use. Although inconvenient, to get the best possible results you have to do this whenever you use paper or ink from a third-party because printer company's only provide profiles for their own paper and inks.

ColorVision's PrintFix has a target that you open on your computer and print out. You then run it through the scanner where the printed colors are compared to the known colors in the parget. The differences are stored in the new printer profile.

To simplify the process of moving colors from one device to another, the International Color Consortium (ICC) has defined a widely accepted format that standardizes device profiles so they can all work together. When implemented throughout the workflow you can move profiles and images with embedded profiles (called *tagged images*) between different applications, hardware, and even operating systems while retaining color fidelity. These *tagged files* let the color engine display and print consistent colors. If a profile isn't attached, you can use an application such as Photoshop to attach one.

If every application and device that you used had it's own color management system, it would be like a tower of babble. To make it easier to develope compatible color management tools, color management must be integrated into the computer's operating system and this has been done. Macintosh computers call theirs ColorSync and Windows calls theirs Integrated Color Management (ICM). These systems enable color management to be uniform among applications such as Photoshop and Quark that support color management. These systems don't actually do color management themselves, but they provide the architecture for a number of important functions. Basically they are just plumbing.

Chapter 12
Pixels and Images



CONTENTS

Just because photography is an art form, it doesn't mean you don't have to know some math. When it comes to displaying or printing your images, this chapter could be entitled "So You Have to Know Arithmetic After All." If your camera captures an image that's 1600 x 1200 pixels in size, what does that mean when you e-mail it, post it to a Web site, or make a print? In this chapter you find out how to answer questions like this.

The calculations we'll be using in this chapter are nothing more than subtraction, addition, multiplication and division—things you mastered early in school. However, to make it easier to explore the various relationships being discussed, you can use the Excel worksheet "Pixels & Images Calculator" on the eBook's CD and downloadable at:

http://www.photocourse.com/tools/pixelcalc.xls

The worksheet has been saved in Excel 5 format so that version and all later versions of Excel can read it. Its file name is pixelcalc.xls.

Pixels and Image Sizes

Let's start with one surprising fact: A pixel has no size or shape. At the time it's born, it's simply an electrical charge much like the static electricity that builds up on your body as you shuffle across a carpet on a dry day. A pixel is only given size and shape by the device you use to display or print it. Understanding how pixels and image sizes relate to one another takes a little effort but you need to bring nothing more to the process than your curiosity and elementary school arithmetic skills.

PIXELS

A pixel begins its life on the camera's image sensor during that flickering moment when the shutter is open. The size of each photosite on the image sensor can be measured, but the pixels themselves are just electrical charges soon to be converted into digital zeros and ones. These numbers, just like any other numbers that run through your head, have no physical size.

This digital image of a buttonbush blossom is 1600 pixels wide and 1200 pixels tall. It's said to be 1600 x 1200.

Although the captured pixels have no physical dimensions, a sensor's size is specified just like a digital photo's, except the count is the number of photosites that it has on its surface. In most cases the numbers are the same since each photosite captures one pixel in the image. This size is usually specified in one of two ways—by the sensor's dimension in photosites, or by its total number of photosites. For example, the same sensor can be said to have 1800 x 1600 pixels (where "x" is pronounced "by" as in "1800 by 1600"), or to contain 2.88-million sites (1800 multiplied by 1600).

Since pixels stored in an image file have no physical size or shape, it's not surprising that the number of pixels doesn't by itself indicate a captured image's sharpness or size. This is because the size of each captured pixel, and the image of which it's a part, is determined by the output device. The device can spread the available pixels over a small or large area on the screen or printout.

If the pixels in an image are squeezed into a smaller area, perceived sharpness increases (from the same viewing distance). Images on high-resolution screens and printouts look sharper only because the available pixels are grouped into a small area—not because there are more pixels.

As pixels are enlarged so the image is spread over a larger area, the image's perceived sharpness falls (from the same viewing distance). If enlarged past a certain point, the individual pixels will begin to show—the image becomes *pixilated*.

To visualize this concept, imagine two tile mosaics, one with small tiles and one with large. If both mosaics cover the same area, the one with small tiles will have more tiles so it can have sharper curves and more detail. However, if you have the same number of large and small tiles, the area covered by the small tiles will be much less. When viewing both from the same distance, the smaller one will .look sharper. However, if you stand close to the small mosaic its sharpness and detail will appear almost identical to the larger one viewed from farther away.

To make an image larger or smaller for a given output device, it must be resized (resampled) in a photo-editing program, or by the application you're printing it with. Resizing is performed by interpolation, and sometimes this is done without your even being aware of it. When an image is made larger, extra pixels are added and the color of each new pixel is determined by the colors of its neighbors. When an image is made smaller, some pixels are deleted.

The aspect ratio of an image sensor determines the shape of your prints.

ASPECT RATIOS

If you have ever tried to centering a photo on an 8.5 x 11 sheet of paper so there are even borders all around the image, you have been dealing with a concept called "*aspect ratios*." This is the ratio between the width and height of an image. For example, a 35 mm slide or negative is 1.5 inches wide by 1 inch tall. Its aspect ratio is 1.5 to 1. A square image has an aspect ratio of 1:1. To calculate the aspect ratio of any camera, divide the largest number in its image size by the smallest number. For example, if a camera captures images 1536 x 1024 pixels in size, divide 1536 by 1024. In this case the aspect ratio is 1.5, the same as 35mm film.

Aspect ratios are often expressed in one of three ways:

- *When expressed as 1.5 to 1 or 1.5:1*, the actual numbers calculated in the division process are used, even though one has a decimal place.
- *To remove the decimal*, the numbers are raised to a new ratio so both numbers are even. In our example, 1.5 to 1 would be raised to 3 to 2. That's what's done with TV screen aspect ratios. The aspect ratio for normal TV is referred to as 4:3 and HDTV as 16:9.
- *In a few cases, where one part of the ratio is assumed to be 1*, just the other part is given. For example, a 1.5:1 ratio is expressed just as 1.5.

Aspect ratios present a problem when printing or displaying images because most cameras don't capture images with the same aspect ratio as the 11 x 8.5 paper we print on—which has an aspect ratio of 1.29 (11 divided by 8.5) and few have the same as the screens we display them on. (See the box "Typical Aspect Ratios" on the next page) Even some software that prints contact sheets crops images—greatly lowering their usefulness when you try to evaluate images for printing. When the aspect ratios don't match, here is what you can do:

- *Crop the image to the desired aspect ratio*. Programs such as Photoshop let you crop or select areas of an image using any aspect ratio that you specify. To do it manually you:

1. Determine the aspect ratio you want to use.

2. Determine how high the image needs to be in pixels.

3. Multiply the height by the aspect ratio to determine how wide the image should be in pixels.

If you know the width and want to find the height, divide the aspect ratio's largest number into the smaller and multiply the width by that number.

- *Enlarge the image so it fills the page or screen* even though some of it extends past one or more edges. In effect, you are cropping the image.
- *Print or display the entire image frame leaving unequal borders around the image*. The image can be centered so the left/right and top/bottom margins are equal.

EXPLORING THE WORKSHEET

Part 1 on the Excel worksheet "Pixels & Images Calculator" calculates the total number of pixels in an image and its aspect ratio when you enter the image's width and height in pixels. The numbers in the descriptions that follow refer to row numbers on the spreadsheet.

1. Image Sizes			
1	Width of image (in pixels)	3,000	pixels
2	Height of Image (in pixels)	2,000	pixels
3	Total number of pixels in image	6,000,000	pixels
4	Aspect ratio	1.50	to 1

1. *Width of image (in pixels)* is where you enter the image's width in pixels.

2. *Height of image (in pixels)* is where you enter the image's height in pixels.

3. *Total number of pixels in image* is calculated by multiplying the image's width by its height.

4. *Aspect ratio* is calculated by dividing the image's width by its height.

EXERCISES

1. Enter the width and height of your own images and see what the total number of pixels is and what aspect ratio it has. You can find image sizes in your camera's user guide. There may be more than one resolution, and if so, try them all. When the resolution changes, does the aspect ratio also change?

2. If a digital camera recorded the following image sizes, how many pixels are there in each image size? What is the aspect ratio for each?

- 2,400 x 1,800 ____________________________
- 1280 x 960 _____________________________
- 640 x 480 ______________________________

TYPICAL ASPECT RATIOS

WIDTH	HEIGHT	ASPECT RATIO
Paper		
4	6	1.5
5	7	1.4
8	10	1.2
8.5	11	1.3
Screen		
640	480	1.3
600	800	1.3
1024	768	1.3
Cameras		
1600	1200	1.3
3000	2000	1.5
TV Standard		4:3
HDTV		16:9

Specifying Image Sizes

TIPS

■ The document size that you specify for an image determines its size if you copy or place it into a document created with another application.

■ Some people swear that when you enlarge an image by resampling it, you get better results if you enlarge it in 10% steps until it reaches the size you want.

There are two ways you can change an image's size—by changing the number of pixels in the image; or by changing the size of the area in which the available pixels are printed or displayed—the document size. These two procedures are separate but related.

■ *Pixel dimensions* specifies the number of pixels an image contains. Initially determined by the number of pixels captured by the camera there are times you may want to change this size by deleting or adding pixels. For example, you may want to e-mail or post an image on a Web site. For this purpose it's best if an image is no larger than the lowest common denominator screen, usually 640 x 480, or 800 x 600. Reducing an image's size also makes the file size smaller so the image can be sent or displayed more quickly. The main reason you would increase the number of pixels in an image is to make large prints. Since most images print best when they are printed at 200-300 ppi you may get better results by enlarging the image rather than letting the pixels per inch fall below 200.

To change the number of pixels in an image, you *resample* it to make it smaller by removing pixels, or larger by adding them. Reducing an image usually has less affect on its appearance than does enlarging one. This is because enlarging requires the program to add pixels—a process called *interpolation*. The computer analyzes adjoining pixels to determine the color of the new ones it inserts. Normally, you can double the size of an image without effects showing. However, trial and error is the only way to be sure because images vary so much. Look for the image becoming soft, as if it's not sharply focused. If you are making other changes to the image, resampling it should be done after all other changes other than sharpening (page 73). This is because most adjustments work best where there are the maximum number of original pixels to work with.

TIP

There are a number of third-party programs available for resizing images.

■ pxl SmartScale from Extensis (www.extensis .com).

■ S-Spline from Shortcut Software (www.s-spline .com).

■ Genuine Fractals from LizardTech (www.lizardtech .com).

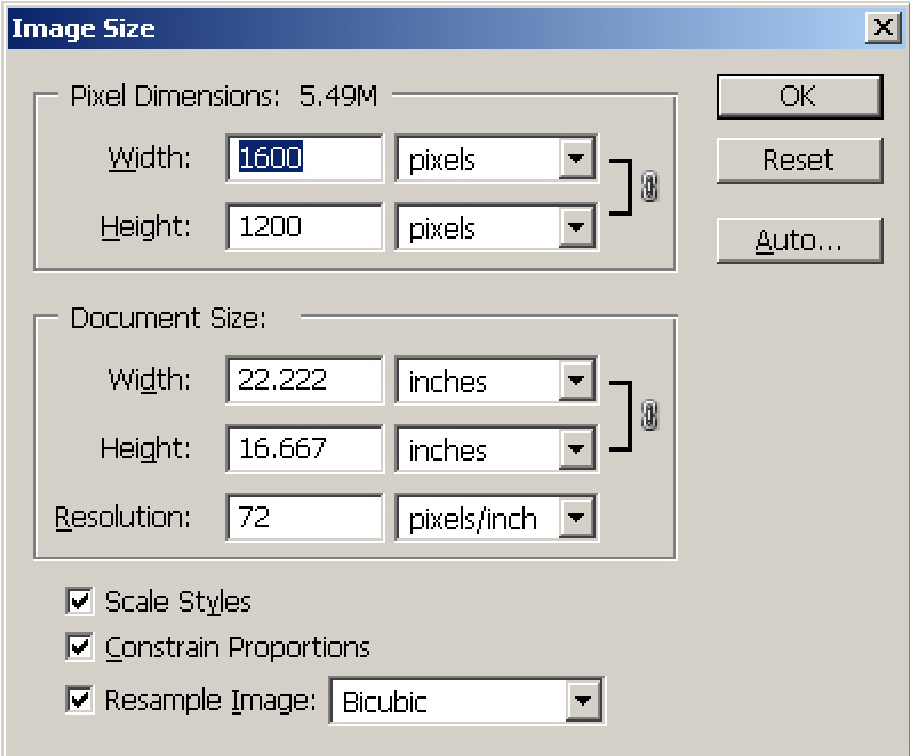
■ *Document size* specifies how large an image will be printed or displayed, especially in other applications. Normally you change the document size with resampling turned off. As a result, as the size increases, the pixels per inch decrease because the same number of pixels are spread over a wider area. If the resolution falls below 200 or so pixels per inch, you may want to consider resampling the image. There are problems printing with less than 200 pixels per inch and with resampling to increase the number of pixels so you'll have to experiment to see which works best for a particular image. Just be sure your image is not too large to fit on the page. Many printers can't print to the edge of the sheet so there is always a border. To print the full image, it must fit inside this border area.

To change either the pixel dimensions or document size, select *Image>Resize>Image Size* in Photoshop Elements or *Image> Image Size* in Photoshop to display the Image Size dialog box having the following settings:

■ *Pixel Dimensions* shows the image's *Width* and *Height* in pixels and next to the heading is the size of the image file. You can click the drop-down arrow to specify changes as a percentage.

■ *Document size* shows you the current *Width* and *Height* of the image in inches, centimeters, or any other unit of measurement you select with the drop-down arrow. *Resolution* displays the image's pixels per inch at the current document size. This number changes as you change image width and height. If you make the image larger, the existing pixels are spread over a

Photoshop's Image Size dialog box.



TIP

■ If you make any mistakes in the dialog box, hold down Alt (Option on Macs) to change the *Cancel* button to *Reset* and click it to start over.

larger area so the pixels per inch decreases. The only way to change this relationship is to add more pixels to the image by resampling it.

■ *Constrain Proportions* check box determines if one of the photo's dimensions will adjust automatically when you change the other. If you turn this off, the image's proportions or aspect ratio changes and the image is stretched in one direction. Unless you are after a special effect, you normally leave this check box on. Chain link icons connecting the width and height settings indicate when this setting is on.

■ *Resample Image* check box determines if the number of pixels in the image will change when you change the size. When specifying a size for printing you usually turn this off. When you resample an image to add or subtract pixels, you can choose a process that trades off quality versus speed. *Nearest Neighbor* is fast but doesn't give the best results, *Bilinear* is faster and gives better results, and *Bicubic*, the default, is slowest but best.

Displaying Images

When a digital image is displayed on the computer screen, its size is determined by three factors—the screen’s resolution setting, the screen’s size, and the number of pixels in the image.

THE SCREEN’S RESOLUTION

The size of each pixel on the screen is determined by the screen’s resolution setting. The resolution is almost always given as a pair of numbers that indicate the screen setting's width and height in pixels. For example, a monitor may be specified as being a low-resolution 640 x 480, a medium resolution of 800 x 600, or a high-resolution of 1024 x 768 or more. (The first number in the pair is the number of pixels across the screen. The second number is the number of rows of pixels down the screen.)

This is a 1024 x 768 display. That means there are 1024 pixels on each row and there are 768 rows of pixels.

At 800 x 600 (top), Photoshop and the image being edited fills the screen. When the screen resolution is increased to 1024 x 786 (middle), the image is smaller and at 1280 x 1024 (bottom) even smaller.

SCREEN RESOLUTION AND IMAGE SIZE

On any given monitor, changing screen resolution changes the size of displayed objects such as icons, text, buttons, and images. As shown in the margin illustrations, as the resolution increases, object sizes decrease but they do appear sharper because each pixel is smaller.

Another way to think about the size of each pixel is in terms of how many pixels are displayed per inch on the screen. The larger the pixels, the fewer fit per inch. As you can see from the table on the facing page, the actual number of pixels per inch (the numbers in italics) depends on both the resolution setting and the size of the monitor. (Advertised screen sizes are based on a diagonal measurement. These sizes are horizontal measurements across the screen so they don't relate exactly to advertised screen sizes.)

If a 14" monitor and a 21" monitor are both set to 800 x 600 pixels, the pixels per inch are different. On the larger screen the same 800 pixels are spread

The numbers in italics in this table are the pixels per inch for each combination of monitor screen width and resolution setting.

	Monitor Size				
Resolution	14"	15"	17"	19"	21"
640 x 480	*60*	*57*	*51*	*44*	*41*
800 x 600	*74*	*71*	*64*	*56*	*51*
1024 x 768	*95*	*91*	*82*	*71*	*65*

along a longer row so the pixels per inch decreases. One number you will often see quoted is 72 ppi. This is supposed to be a magic number in digital imaging. Its origins are said to go back to early Apple computer monitors that had that setting. However, it no longer has any meaning except as an approximate average for all monitors. It may as well be 62 or 82. As you can see from the table above, images can be displayed at a variety of ppi—it all depends on the monitor, not the image. The table shows a range of ppi from 41 to 95 but newer monitors with resolutions of 1280 x 1024 and higher have even more pixels per inch. It's best to forget the 72 ppi number and think of screen resolutions when sizing images for display on the screen. If their width and height in pixels is less than the screen's resolution, they will be fully displayed. If they are larger, the viewer can only see part of the image at a time and will have to scroll around it—somewhat like reading a newspaper with a magnifying glass. For this reason, most images to be sent by e-mail or posted on a Web site are sized so they are no larger than 600–800 pixels wide or 400–600 pixels high.

EXPLORING THE WORKSHEET

Part 2 on the Excel worksheet "Pixels & Images Calculator" calculates the size of an image displayed on the screen. The numbers in the descriptions that follow refer to row numbers on the spreadsheet.

2. Displaying Images			
1	Width of image (in pixels)	3,000	pixels
2	Height of image (in pixels)	2,000	pixels
3	Screen's horizontal width (in inches)	16	inches
4	Screen's horizontal resolution (in pixels)	1,024	pixels
5	Screen's ppi	64.0	ppi
6	Width of image on screen (in inches)	46.9	inches
7	Height of image on screen (in inches)	31	inches
8	Will image fit on screen?	NO	

1. *Width of image (in pixels)* is where you enter the image's width in pixels.

2. *Height of image (in pixels)* is where you enter the image's height in pixels.

3. *Screen's horizontal width (inches)* is where you enter your screen's width in inches (not its advertised diagonal measurement).

4. *Screen's horizontal resolution (pixels)* is where you enter your screen's horizontal resolution. For example, if resolution is set to 800 x 600, enter 800. If it's set to 1024 x 768, enter 1024.

6. *Screen's PPI* (pixels per inch) is calculated by dividing the screen's horizontal resolution in pixels (line 4) by its actual width in inches (line 3). In the illustration above it divides 1024 by 16 for a ppi of 64.

TIP: CHECKING YOUR SYSTEM

To see what resolution your Windows system is set to, right-click the desktop and click the *Properties* command to display a tabbed dialog box. Click the *Settings* tab on the dialog box and check the *Screen* setting.

7. *Width of image on screen (in inches)* is calculated by dividing the width of the image in pixels (line 1) by the screen's ppi (line 5). In the illustration above it divides 3000 by 64 for an image width of 46.9 inches.

8. *Height of the image on screen (in inches)* is calculated by dividing the height of the image in pixels (line 2) by the screen's ppi (line 5).

9. *Will image fit on screen?* is calculated by comparing the width of the image in pixels (line 1), with the screen's horizontal resolution in pixels (line 4). If the image is equal to or smaller than the screen (in pixels), it will fit (*YES*), otherwise it won't (*NO*).

EXERCISES

1. If your image is 1600 x 1200 pixels, how wide will it be when displayed on your screen? Will it fit?

2. If your image is 1200 x 800 pixels, how large will it be when displayed on your screen? Will it fit?

PRINTING IMAGES

TIP

Understanding printer resolutions is complicated by their advertised resolutions. The advertised dpi refers to the number of individual dots of ink the printer can print per inch. However, anywhere from 4 to 8 colors and many dots are needed to print a pixel of a specific color. For this reason, the actual resolution, as measured in pixels is significantly lower than advertised.

Printer resolutions are usually specified by the number of dots per inch (dpi) that they print. (Generally ppi—pixels per inch—refer to the image and display screen, and dpi—dots per inch—refer to the printer and printed image. In this book we sometimes use them interchangeably.)

For comparison purposes, monitors use somewhat less than 100 ppi to display text and images, inkjet printers range up to 1700 dpi or so (see Tips box opposite), and commercial typesetting machines range between 1,000 and 2,400 dpi. For most purposes, digital images print best at 200 or 300 dpi.

Since image sizes are described in pixels and photographic prints in inches, you sometimes have to convert between these units. To do so, you divide the image's dimension in pixels by the resolution of the device in dots per inch (dpi). For example, to convert the dimensions for a 1500 x 1200 image being printed at 300 ppi you divide as follows:

Width: 1500 pixels ÷ 300 dpi = 5"

Height: 1200 pixels ÷ 300 dpi = 4"

The result is a 5" x 4" print. However, if the output device prints 600 dpi, the print size falls to 2.5" x 2" as follows:

Width: 1500 pixels ÷ 600 dpi = 2.5"

Height: 1200 pixels ÷ 600 dpi = 2"

This graphic shows the relative sizes of a 3000 x 2000 image printed or displayed on devices with different dots per inch. At 72 dpi it's 41.7" x 27.8", at 300 dpi it's 10" by 7", and at 1500 dpi, it's only 2" x 1.3"—a little larger than a stamp.

EXPLORING THE WORKSHEET

Part 3a on the Excel worksheet "Pixels & Images Calculator" calculates the size of print you can expect from a given file size and the dpi you choose to print at. The numbers in the descriptions that follow refer to row numbers on the spreadsheet.

3a. Printing Images-Print Sizes			
1	Width of image (in pixels)	1,600	pixels
2	Height of image (in pixels)	1,200	pixels
3	Printer's resolution (in dpi)	200	dpi
4	Width of print (in inches)	8.00	inches
5	Height of print (in inches)	6.00	inches

1. *Width of image (in pixels)* is where you enter the image's width in pixels.

2. *Height of image (in pixels)* is where you enter the image's height in pixels.

3. *Printer's resolution (in dpi)* is where you enter the resolution your printer uses (this isn't the same as the number of ink drops it sprays, and is usually set in a photo-editing program).

4. *Width of print (in inches)* is calculated by dividing the width of the image in pixels (line 1) by the dots-per-inch used to print it (line 3).

5. *Height of print (in inches)* is calculated by dividing the height of the image in pixels (line 2) by the dots-per-inch used to print it (line 3)

EXERCISES

1. If your image is 1600 x 1200 and you print it at 600 dpi, how big will the print be?

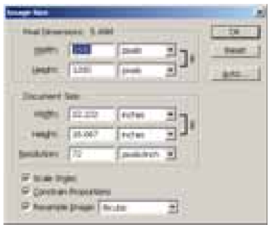
2. If your image is 800 x 600 and you print it at 300 dpi, how big will the print be?

3. If you print an image at 300 dpi, how wide will it have to be in pixels, to get a 6-inch wide print?

4. Using the original widths and heights listed below and the specified printer dpi's, calculate the width and height of the prints you'd get.

- Original 800 x 600, printed at 300 dpi is ____ x ____
- Original 800 x 600, printed at 600 dpi is ____ x ____
- Original 1600 x 1200, printed at 300 dpi is ____ x ____
- Original 1600 x 1200, printed at 600 dpi is ____ x ____
- Original 1800 x 1600, printed at 300 dpi is ____ x ____
- Original 1800 x 1600, printed at 600 dpi is ____ x ____

UNDERSTANDING PIXELS PER INCH



In Photoshop, you can display the image size dialog box, turn off "Resample Image" and then specify any print size. The resolution of the image is calculated and displayed in pixels per inch. If it's between 200–300, the results should be good on most inkjet printers.

Normally you don't have to change the number of pixel's in an image to change the size of a printout. That task is handled by the software program you use to print the image. For example, if you place an image in a program such as QuarkXpress or PageMaker, it's automatically printed at the size you specify in those programs. In Photoshop you specify the print size (called its *document size*) independently of the image size (called its *pixel dimensions*).

One thing to keep in mind is that if you enlarge a print too much, it won't be as sharp as you may desire. That's because a certain minimal number of dots per inch, usually between 200 and 300 are needed to get a good print. Pixels begin to show when the print is enlarged to a point where the dots per inch (dpi) fall too low. If your printer prints the sharpest images at 300 dpi, you need to determine if the size of the image you plan on printing will fall below this level. To do so, you divide the chosen dpi by the width of the image in inches. For example, if you print an image that's 1600 pixels wide so the print is 10" wide, there are only 160 dots per inch (1600 pixels ÷ 10 inches = 160 pixels per inch). However, if you print the same image so it's 5 inches wide, the dots per inch climbs to over 300.

EXPLORING THE WORKSHEET

Part 3b on the Excel worksheet "Pixels & Images Calculator" calculates the dpi of a print when you use a program that automatically resizes a file for printing.

3b. Printing Images-DPI			
1	**Width of digital image (in pixels)**	1,600	pixels
2	**Height of image (in pixels)**	1,200	pixels
3	**Desired width of print (in inches)**	6	inches
4	**Height of print (in inches)**	4.5	inches
5	**DPI (dots-per-inch)**	267	dpi

1. *Width of image (in pixels)* is where you enter the image's width in pixels.

2. *Height of image (in pixels)* is where you enter the image's height in pixels.

3. *Desired width of print (in inches)* is where you enter the width of the print you want in inches.

4. *Height of print (in inches)* is calculated so the print has the same aspect ratio as the image. The formula is in the form of a:b::c:d.

5. *DPI (dots per inch)* is calculated by dividing the width of the image in pixels (line 1) by the desired width in inches (line 3).

EXERCISES

1. If you print a 4 x 6 image from an 1800 x 1600 file, how many dpi will there be along the long dimension?

2. If you print a 4 x 6 image from an 1800 x 1600 file, how many dpi will there be along the short dimension?

Color Depth and File Size

TIP: CHECKING YOUR SYSTEM

You may have to set your system to full-color, it doesn't happen automatically. To see if your Windows system supports true color (not all do), right-click the desktop and click the *Properties* command to display a tabbed dialog box. Click the *Settings* tab on the dialog box and check the *Color* setting.

Resolution isn't the only factor governing the quality of your images. Equally important is the number of colors in the images. When you view a natural scene, or a well done photographic color print, you are able to differentiate millions of colors. Digital images can approximate this color realism, but whether they do so on your system depends on its capabilities and its settings. How many colors there are in an image, or how many a system can display is referred to as *color depth*, *pixel-depth*, or *bit depth*. Almost all newer systems include a video card and a monitor that can display what's called 24-bit true color. It's sometimes called *true color* because these systems display 16 million colors, about the number the human eye can discern.

How do bits and colors relate to one another? It's simple arithmetic. To calculate how many different colors can be captured or displayed, simply raise the number 2 to the power of the number of bits used to record or display the image. For example, 8-bits gives you 256 colors because $2^8=256$. Here's a table to show you some other possibilities.

NAME	BITS PER PIXEL	FORMULA	NUMBER OF COLORS
Black and white	1	2^1	2
Windows display	4	2^4	16
Gray scale	8	2^8	256
256 color	8	2^8	256
High color	16	2^{16}	65 thousand
True color	24	2^{24}	16 million
RAW/TIFF images	48	2^{48}	281 trillion

Black and white images require only 2-bits to indicate which pixels are white and which are black. Gray scale images need 8 bits to display 256 different shades of gray. Color images are displayed using 4 bits (16 colors), 8 bits (256 colors), 16 bits (65 thousand colors) called *high color*, and 24 bits (16 million colors) or true color. Some cameras and image formats use up to 48 bits per pixel. These extra bits are used to improve the color in the image as it is processed down to its 24-bit final form.

In addition to affecting image quality, color depth also has an impact on file sizes. The more bits assigned to each pixel, the larger an image file becomes.

EXPLORING THE WORKSHEET

Part 4 on the Excel worksheet "Pixels & Images Calculator" calculates the total number of pixels in an image when you enter the image's width and height in pixels.

REVIEW: BITS AND BYTES

■ When reading about digital systems, you frequently encounter the terms *bit* and *byte*.

● The *bit* is the smallest digital unit. It's basically a single element in the computer that like a light bulb has only two possible states, on (indicating 1) or off (indicating 0). The term *bit* is a contraction of the more descriptive phrase *binary digit*.

● *Bytes* are groups of 8-bits linked together for processing. Since each of the eight bits has two states (on or off), the total amount of information that can be conveyed is 2^8 (2 raised to the 8th power), or 256 possible combinations.

4. Color Depth and File Sizes

1	**Bits per color**	8	
2	**Bits per pixel**	24	
3	**Number of possible colors**	16,777,216	
4	**Width of image (in pixels)**	1,600	pixels
5	**Height of image (in pixels)**	1,200	pixels
6	**Total number of pixels in image**	1,920,000	pixels
7	**File size (uncompressed)**	46,080,000	bits
		5,760,000	bytes
		5,625	kilobytes
		5.5	megabytes

8 **Table of color depths**

Name	Bits per pixel	
Black and white images	1	
Gray scale/GIF images	8	
High color	16	
True color/JPEG Images	24	(8 for each color-R, G, and B)
RAW and TIFF	48	(16 for each color-R, G, and B)

1. *Bits per color* is where you enter the number of bits your image uses for each color—red, green, and blue.

2. *Bits per pixel* is calculated by a formula that multiplies bits per color (line 1) by 3 since three colors are used for each pixel.

3. *Number of possible colors* is calculated by raising the number 2 to number of bits per pixel (line 2).

4. *Width of image (in pixels)* is where you enter the image's width in pixels.

5. *Height of image (in pixels)* is where you enter the image's height in pixels.

6. *Total number of pixels in image* is calculated by multiplying the image's width by its height.

7. *File size* (uncompressed) is calculated by multiplying the total number of pixels in the image by the number of bits used to store each pixel. File sizes are shown in bits, bytes, kilobytes, and megabytes.

8. Table of color depths shows color depths used by various image types.

EXERCISES

1. If an image assigns the following number of bits to each pixel, how many colors can be displayed?

■ 2 bits = __________ colors ■ 8 bits = __________ colors

■ 16 bits = __________ colors ■ 24 bits = __________ colors

■ 32 bits = __________ colors ■ 36 bits = __________ colors

2. If an image is 3000 x 2000 pixels and 32 bits of color, how large is the file in megabytes? _________

Appendices

CONTENTS

There isn't much to say when introducing an appendix because the contents are usually things that didn't fit well else where in the book. In this appendix is a glossary of terms used in the book and a guide to understanding copyright protections for you and others. Other sections cover scanning slides, negatives and prints and capturing images in high-quality RAW formats.

A. Glossary

GLOSSARY

"an alphabetical list of technical terms in some specialized field of knowledge; usually published as an appendix to a text on that field." (Found by typing *define: glossary* into Google)

Angle of view. The amount of a scene that can be recorded by a particular lens; determined by the focal length of the lens.

Adapter. Used to insert a smaller storage device into a larger slot in a computer or other device.

Additive color system. See RGB.

Aperture, maximum. The largest size of the hole though which light enters the camera.

Aperture. The lens opening formed by the iris diaphragm inside the lens. The size of the hole can be made larger or smaller by the autofocus system or a manual control.

Aspect ratio. The ratio between the width and height of an image or image sensor.

ATA. A standard for storage devices that lets them be treated as if they were hard drives on the system. Any ATA compatible media can be read by any ATA device.

Attachment. A file such as a photography sent along with an e-mail message so it can be viewed or saved at the recipient's end.

Automatic exposure. A mode of camera operation in which the camera automatically adjusts the aperture, shutter speed, or both for proper exposure.

Automatic flash. An electronic flash unit with a light-sensitive cell that determines the length of the flash for proper exposure by measuring the light reflected back from the subject.

Back-lit. The subject is illuminated from behind and will be underexposed unless you use fill flash or exposure compensation.

Bayer pattern. A pattern of red, green, and blue filters on the image sensor's photosites. There are twice as many green filters as the other colors because the human eye is more sensitive to green and therefore green color accuracy is more important.

Bit-mapped. Images formed from pixels with each pixel a shade of gray or color. Using 24-bit color, each pixel can be set to any one of 16 million colors.

Burst mode. The ability of a camera to take one picture after another as long as you hold down the shutter release button.

Card. The sealed package containing storage chips or other devices with electrical connectors that make contact when inserted into a card slot on a camera, printer, computer, or other device..

CCD raw format. The uninterpolated data collected directly from the image sensor before processing.

CCD. See Charge-coupled device.

Charge-coupled device (CCD). An image sensor that reads the charges built up on the sensor's photosites a row at a time.

CMOS image sensor. An image sensor created using CMOS technology.

CMOS. See CMOS image sensor.

Color balance. The overall accuracy with which the colors in a photograph match or are capable of matching those in the original scene.

Color depth. The number of bits assigned to each pixel in the image and the number of colors that can be created from those bits. True Color uses 24 bits per pixel to render 16 million colors.

CompactFlash. A popular form of flash storage for digital cameras.
Compression, lossless. A file compression scheme that makes a file smaller without degrading the image.
Compression, lossy. A file compression scheme that reduces the size of a file but degrades it in the process so it can't be restored to its original quality.
Compression. The process of reducing the size of a file.
Depth of field. The distance between the nearest and farthest points that appear in acceptably sharp focus in a photograph. Depth of field varies with lens aperture, focal length, and camera-to-subject distance.
Docking station. A small base connected to the computer by a cable. You insert the camera or other device into the docking station to transfer images.
Download. Sending a file from another device to your computer.
Exposure. 1. The act of allowing light to strike a light-sensitive surface. 2. The amount of light reaching the image sensor, controlled by the combination of aperture and shutter speed.
Exposure compensation. The ability to adjust exposure by one or two stops to lighten or darken the image.
Exposure/focus lock. The ability to point at one part of the scene and hold the shutter button halfway down to lock in exposure and focus settings when you point the camera elsewhere to compose the scene.
Firewire. Apple's name for IEEE 1394.
Flash card reader. An accessory that attaches to your computer by cable. You insert a flash memory card into the reader to transfer files.
Flash memory card. A card containing chips that store images.
Flash memory. A form of memory using chips instead of magnetic media. The data in the device isn't lost when the power is turned off.
Flash, fill. Flash used to fill shadows even when there is enough light to otherwise take the photograph.
Flash, ring. A special circular flash that fits over a lens to take close-up pictures
Flash, slave. A flash that fires when it senses the light from another flash unit.
FlashPix. An image format that contains a number of resolutions, each of which is broken into tiles that can be edited and displayed independently.
Floppy drive. A storage device, no longer found on most computers, that accepts 3.5 or 5.25-inch floppy disks.
Focal length. The distance from the optical center of the lens to the image sensor when the lens is focused on infinity. The focal length is usually expressed in millimeters (mm) and determines the angle of view (how much of the scene can be included in the picture) and the size of objects in the image. The longer the focal length, the narrower the angle of view and the more that objects are magnified.
Focus lock. See Exposure/focus lock.
Focus. The process of bringing one plane of the scene into sharp focus on the image sensor.
Frame grabber. A device that lets you capture individual frames out of a video camera or off a video tape.

Frame Rate. The number of pictures that can be taken in a given period of time.
f-stop. A numerical designation (f/2, f /2.8, etc.) indicating the size of the aperture (lens opening).
GIF. An image file format designed for display of line art on the Web.
Gray market. Importing camera equipment outside of the normal manufacturer's distribution channels to take advantage of lower prices elsewhere in the world.
Gray scale. A series of 256 tones raging from pure white to pure black.
Guide number. A rating of a flash's power.
Hot shoe. A clip on the top of the camera that attaches a flash unit and provides an electrical link to synchronize the flash with the camera shutter.
IEEE 1394. A new port on the computer capable of transferring large amounts of data. Currently the fastest available port.
i.Link. Sony's name for IEEE 1394.
Image sensor. A solid-state device containing a photosite for each pixel in the image. Each photosite records the brightness of the light that strikes it during an exposure.
Infrared. See IrDA.
International Organization for Standardization. See ISO.
Interpolation. In an image interpolation adds extra pixels. It's done with some zoom lenses.
Inverse square law. The physical law that causes light from a flash to fall off in such a way that as flash to subject distance doubles, the light falls off by a factor of four.
IrDA. An agreed upon standard that allows data to be transferred between devices using infrared light instead of cables..
ISO. A number rating indicating the relative sensitivity to light of an image sensor or photographic film. Faster film (higher ISO) is more sensitive to light and requires less exposure than does slower film.
JPEG. A very popular digital camera file format that uses lossy compression to reduce file sizes. Developed by the Joint Photographic Experts Group.
Landscape mode. Holding the camera in its normal orientation to hake a horizontally oriented photograph.
Lempel-Ziv-Welch. See LZW.
LiOn. Lithium ion battery.
Long-focal-length lens (telephoto lens). A lens that provides a narrow angle of view of a scene, including less of a scene than a lens of normal focal length and therefore magnifying objects in the image.
Lossless. See Compression, lossless.
Lossy. See Compression, lossy.
LZW. A compression scheme used to reduce the size of image files.
Macro mode. A lens mode that allows you to get very close to objects so they appear greatly enlarged in the picture.
Matrix Metering. An exposure system that breaks the scene up into a grid and evaluates each section to determine the exposure.
Megapixel. An image or image sensor with over one million pixels.
Memory stick. A flash memory storage device developed by Sony.
Moore's Law. Gordon Moore's law that predicted that the number of transistors on a chip would double every 18 months.
Motion Pictures Expert Group. See MPEG.

MPEG. A digital video format developed by the Motion Pictures Expert Group.

Multi-megapixel. An image or image sensor with over two million pixels.

Multiple exposure mode. A mode that lets you superimpose one image on top of another.

Multiple exposure. An image made up of two or more images superimposed in the camera.

NiCad. Nickel cadmium battery.

NiMH. Nickel metal hydride battery. Ecologically safe and very efficient.

Noise. Pixels on the image sensor that misread the light.

Normal-focal-length lens. A lens that provides about the same angle of view of a scene as the human eye and that does not seem to magnify or diminish the size of objects in the image unduly.

NTSC. A US video out standard to display images on a TV screen.

Open up. To increase the size of the lens aperture. The opposite of stop down.

Operating system. The program that controls the camera's or computer's hardware.

Optical viewfinder. See Viewfinder.

Orientation sensor. A sensor that knows when you turn the camera to take a vertical shot and rotates the picture so it won't be displayed on it's side when you view it.

Overexposure. Exposing the image sensor to more light than is needed to render the scene as the eye sees it. Results in a too light photograph.

PAL. A European video out standard to display images on a TV screen.

Panorama. A photograph with much wider horizontal coverage that a normal photograph, up to 360-degrees and more.

Panoramic mode. A digital camera mode that uses just the center band on the image sensor to capture an image that is much wider than it is tall.

Parallax. An effect seen in close-up photography when the viewfinder is offset by some distance from the lens. The scene through the viewfinder is offset from the scene through the lens.

Parallel port. A port on the computer that is faster than a serial port but slower than SCSI, USB, or IEEE 1394 ports. Often used by printers and flash card readers.

PC card. A card, in the case of cameras usually a storage device, that plugs into a slot in a notebook or hand-held computer. Originally called PCMCIA cards.

PCMCIA card. See PC Card.

Photosite. A small area on the surface of an image sensor that captures the brightness for a single pixel in the image. There is one photosite for every pixel in the image.

Picture elements. See Pixels.

Pixelization. An effect seen when you enlarge a digital image too much and the pixels become obvious.

Pixels. The small picture elements that make up a digital photograph.

Port. An electrical connection on the computer into which a cable can be plugged so the computer can communicate with another device such as a printer or modem.

Portrait mode. Turning the camera to take a vertically oriented photograph.

Preview screen. A small LCD display screen on the back of the camera used to compose or look at photographs.

SCREEN & IMAGE RESOLUTIONS

Standard image sizes include the following names and dimensions in pixels:

QQCIF—88 x 72
QQVGA—160 x 120
QCIF—176 x 144
CGA 320 x 200
QVGA—320 x 240
CIF— 352 x 288
EGA 640 x 350
VGA 640 x 480
SVGA 800 x 600
XGA 1024 x 768
SXGA 1280 x 1024
WXGA 1366 x 768
SXGA+ 1400 x 1050
UXGA 1600 x 1200
WSXGA+ 1680 x 1050
WUXGA 1920 x 1200
QXGA 2048 x 1536
QSXGA 2560 x 2048
QUXGA 3200 x 2400
WQUXGA—3840 x 2400

Prosumer. A very serious photographer who can be either an amateur or professional.

Rangefinder. A camera design that has a viewfinder separate from the lens.

RAW. An image file containing all of the data captured by the image sensor but not processed in the camera. The highest quality image format.

Read out register. The part of a CCD image sensor that reads the charges built up during an exposure.

Recycle time. The time it takes to process and store a captured image.

Red-eye reduction mode. A mode that fires a preliminary flash to close the iris of the eye before firing the main flash to take the picture.

Red-eye. An effect that causes peoples eyes to look red in flash exposures.

Refresh rate. The time it takes the camera to capture the image after you press the shutter release.

Removable media. Storage media that can be removed from the camera.

Resolution, interpolated. A process that enlarges an image by adding extra pixels without actually capturing light from those pixels in the initial exposure.

Resolution, optical. The true resolution of an image based on the number of photosites on the surface of the image sensor.

Resolution. An indication of the sharpness of images on a printout or the display screen. It is based on the number and density of the pixels used. The more pixels used in an image, the more detail can be seen and the higher the image's resolution.

RGB. The color system used in most digital cameras where red, green, and blue light is captured separately and then combined to create a full color image.

Scanner. An input device that uses light to read printed information including text, graphics, and bar codes, and transfers it into the computer in a digital format.

SCSI port. A port that's faster than the serial and parallel ports but slower and harder to configure than the newer USB port. Also know as the Small Computer System Interface.

Serial port. A very slow port on the computer used mainly by modems. Many digital cameras come equipped with cable to download images through this port but it's slow! Both parallel and USB ports are faster connections.

Short-focal-length lens (wide angle). A lens that provides a wide angle of view of a scene, including more of the subject area than does a lens of normal focal length.

Shutter Speed. The length of time the shutter is open and light strikes the image sensor.

Shutter. The device in the camera that opens and closes to let light from the scene strike the image sensor and expose the image.

Shutter-priority mode. An automatic exposure system in with you set the shutter speed and the camera selects the aperture (f-stop) for correct exposure.

Single-lens reflex. See SLR.

SLR. A type of camera with one lens which is used both for viewing and taking the picture.

SmartMedia. A popular form of flash memory card.

Spot Metering. Autoexposure is based on a meter reading of a small circle in the center of the viewfinder.

Stop 1. An aperture setting that indicates the size of the lens opening. 2. A change in exposure by a factor of two. Changing the aperture from one setting to the next doubles or halves the amount of light reaching the image sensor. Changing the shutter speed from one setting to the next does the same thing. Either changes the exposure one stop.

Stop down. To decrease the size of the lens aperture. The opposite of open up.

Tagged Image File Format. See TIFF.

Telephoto lens. See Long-focal-length lens.

Thru-the-lens. See TTL.

TIFF. A popular lossless image format used in digital photography.

Time-lapse photography. Taking a series of pictures at preset intervals to show such things as flower blossoms opening.

TTL. A camera design that let's you compose an image while looking at the scene through the lens that will take the picture. Also called thru-the-lens.

Unbundling. When a dealer removes normally included items from a camera package and then sells them to you separately.

Underexposure. Exposing the film to less light than is needed to render the scene as the eye sees it. Results in a too dark photograph.

Upload. Sending a file from your computer to another device.

URL (Uniform Resource Locator). The address of a Web site.

USB port. A high-speed port that lets you daisy-chain devices (connect one device to another).

VGA. A resolution of 640 x 480.

Video card. A card the fits into a computer's expansion slot so you can edit digital video.

Viewfinder. A separate window on the camera through which you look to compose images.

White balance. An automatic or manual control that adjusts the brightest part of the scene so it looks white.

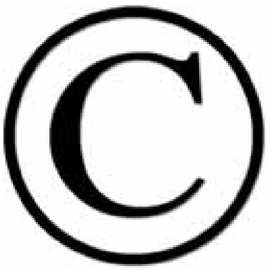
Wide-angle lens. See Short-focal-length lens.

Zoom lens. A lens that lets you change focal lengths on the fly.

B. Understanding Copyright

COPYRIGHT

“A legal right (usually of the author or composer or publisher of a work) to exclusive publication production, sale and distribution of some work.” (Found by typing *define: copyright* into Google)



The copyright symbol.

SOURCES TO VISIT

- American Society of Media Photographers (http://www.asmp.org).
- U.S. Copyright Office (http://www.loc.gov/copyright).
- The World Intellectual Property Organization (http://www.wipo.int/treaties/ip/index.html).

In most countries it is recognized that writers, artists, programmers, sculptors, and entertainers have a right to control the use of their own work—a position that photographers such as yourself applaud. Generally these rights are spelled out in copyright laws that are enforced by the federal government. For example, in the United States, they are protected in the U.S. Constitution (Article I, Section 8) that grants the right to copyright works so as "To promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."

COPYRIGHTS AND PLAGIARISM

When you find interesting text or illustrations in print or on the Web, there is a tendency to want to print them out or save them on your disk. In most, but not all cases, this is perfectly legal and ethical. Problems begin to arise however, when you decide to distribute the material or incorporate some or all of it in one of your own reports, presentations, or Web sites. Because this use is no longer personal it raises two big questions: copyright infringement and plagiarism. Almost any material that you find in print or electronic form is copyrighted—the rights to use it belong solely to the owner of that copyright. However, even uncopyrighted materials are protected. Using the material without written permission violates the owner’s rights and subjects you and your school or organization to penalties and embarrassment. In addition, even when materials are not copyrighted or even if you have written permission to use them, you could be guilty of plagiarism—the representation of someone else’s work as your own. Let’s look at an example. The paragraphs in the following section "What are copyrights?" are adapted directly from the U.S. Library of Congress’ page on the Web. Including this material in this text without written permission is legal in this case because many (but not all) government materials fall into what is called the *public domain*. The author also avoids a charge of plagiarism because he credits the source of the text and does not claim it to be his own.

WHAT ARE COPYRIGHTS?

Copyright is a form of protection provided by the laws of the United States (title 17, U.S. Code) to the authors of "original works of authorship" including literary, dramatic, musical, artistic, and certain other intellectual works. This protection is available to both published and unpublished works. Section 106 of the Copyright Act generally gives the owner of copyright the exclusive right to do and to authorize others to do the following:

- To reproduce the copyrighted work in copies or phonorecords;
- To prepare derivative works based upon the copyrighted work;
- To distribute copies or phonorecords of the copyrighted work to the public by sale or other transfer of ownership, or by rental, lease, or lending;
- To perform the copyrighted work publicly, in the case of literary, musical, dramatic, and choreographic works, pantomimes, and motion pictures and other audiovisual works; and
- To display the copyrighted work publicly, in the case of literary, musical, dramatic, and choreographic works, pantomimes, and pictorial, graphic, or

sculptural works, including the individual images of a motion picture or other audiovisual work.

It is illegal for anyone to violate any of the rights provided by the Act to the owner of copyright. These rights, however, are not unlimited in scope. In some cases, these limitations are specified exemptions from copyright liability. One major limitation is the doctrine of "fair use."

FAIR USE

- criticism
- comment
- news stories
- teaching
- scholarship
- research

WHAT IS FAIR USE?

Is copying that article from a Web magazine or newspaper into an e-mail message to a friend fair use? Nope, you're infringing the owners copyright. Basically, the copyright law says "...the fair use of a copyrighted work, including such use by reproduction for purposes such as criticism, comment, news reporting, teaching (including multiple copies for classroom use), scholarship, or research, is not an infringement of copyright." Even for these uses, whether a specific use is fair or not depends on a number of factors.

1. The purpose and character of the use, including whether such use is of a commercial nature or is for nonprofit educational purposes.

2. The nature of the copyrighted work.

3. The amount and substantiality of the portion used in relation to the copyrighted work as a whole.

4. The effect of the use upon the potential market for or value of the copyrighted work.

The U.S. Copyright Office Web site.

WHAT IS PUBLIC DOMAIN?

When something is in the public domain, you're free to use it any way you see fit. However, you are still expected to credit the source and not claim it as your own. How do you know if something is in the public domain? Partly it is common sense. Recent ads, logos, cartoon characters, illustrations, or photographs are almost certainly not in the public domain. However, 19th century photographs and illustrations most likely are. In that gray area from 1900 through 1970 or so, some things remain protected while others don't. What is protected and what isn't depends on what type of property it is and when it was first copyrighted. If you have questions, you have to search the records of the U.S. Copyright Office yourself, or hire a qualified researcher (or the Copyright Office itself), to do the search for you. Even then, the Copyright Office states "Copyright searches cannot be considered conclusive... but at least will show a good faith effort. The responsibility of determining whether to use an item or not rests with you." Just to muddy the waters for you, even though something hasn't been registered with the Copyright Office doesn't mean it isn't protected by what's called a common law copyright. A good source of copyright information is the United States Copyright Office (http://www.loc.gov/copyright).

WORK CREATED COPYRIGHT TERMS

Works Originally Created On or After January 1, 1978—Automatically protected from the moment of its creation for a term enduring for the author's life, plus an additional 50 years after the author's death. For works made for hire, and for anonymous and pseudonymous works (unless the author's identity is revealed in Copyright Office records), the duration of copyright will be 75 years from publication or 100 years from creation,

C. Caring For Your Camera

Some of the best opportunities for interesting photographs occur during what non-photographers might call bad weather. You can take advantage of these opportunities as long as you take a few precautions to protect your camera.

A digital camera will last through at least 100,000 shots if properly cared for. Under normal circumstances your camera and lens need less cleaning than you might imagine. Since there is always the possibility that the camera or lens might be damaged during cleaning, do so only when necessary. Do check the camera periodically, however.

On a rainy day you can shoot from under an overhang or even an umbrella.

CLEANING THE CAMERA AND LENS

The outside of the camera can be cleaned with a soft, lint-free cloth. Open the "flaps" to the memory and battery compartments occasionally and use a soft brush or blower to remove dust. Rubbing alcohol (isopropyl alcohol) on a Q-tip can be used to clean metal parts of the camera if necessary.

The first rule is to clean the lens only when absolutely necessary. A little dust on the lens won't affect the image, so don't be compulsive. When needed, use a soft brush, such as a sable artist's brush, and a blower (an ear syringe makes a good one) to remove dust. Fingerprints can be very harmful to the lens coating and should be removed as soon as possible. Keep the lens covered when not in use to reduce the amount of cleaning required.

Clean a lens by first using a brush or blower to remove abrasive dust particles. Then use a lens cleaning cloth (or roll up a piece of photographic lens cleaning tissue and tear the end off to leave a brush like surface). Put a small drop of lens cleaning fluid on the end of the tissue. (Your condensed breath on the lens also works well.) Never put cleaning fluid directly on the lens; it might run between the lens elements. Using a circular motion, clean the lens surface with the tissue, then use the cloth or a tissue rolled and torn the same way to dry. Never reuse tissues and don't press hard when cleaning because the front element of the lens is covered with a relatively delicate lens coating.

AVOID STRONG MAGNETIC FIELDS

Never place the camera near electric motors or other devices that have strong magnetic fields. These fields can corrupt the image data stored in the camera.

PROTECTING YOUR CAMERA FROM THE ELEMENTS

Your camera should never be exposed to excessively high temperatures. If at all possible, don't leave the camera in a car on a hot day if the sun is shining on the car (or it will later when the sun changes position). If the camera has to be exposed to the sun, such as when you are at the beach, cover it with a light colored and sand free towel or piece of tinfoil to shade it from the sun. Dark materials will only absorb the heat and possibly make things worse. Indoors, avoid storage near radiators or in other places likely to get hot or humid.

When it's cold out, keep the camera as warm as possible by keeping it under your coat. Always carry extra batteries. Those in your camera may weaken at low temperatures just as your car battery weakens in winter. Prevent condensation when taking the camera from a cold area to a warm one by wrapping the camera in a plastic bag or newspaper until its temperature climbs to that

Eric laughs in the face of danger as a giant wave hits the seawall behind him.

When it's cold, keep the camera or battery under your coat to keep it warm.

of the room. If some condensation does occur, do not use the camera or take it back out in the cold with condensation still on it or it can freeze up camera operation. Remove any batteries or flash cards and leave the compartment covers open until everything dries out.

Always protect equipment from water, especially salt water, and from dust, dirt, and sand. A camera case helps, but at the beach a plastic bag is even better. When shooting in the mist, fog, or rain, cover the camera with a plastic bag into which you've cut a hole for the lens to stick out. Use a rubber band to seal the bag around the lens. You can reach through the normal opening in the bag to operate the controls. Screwing a skylight filter over the lens allows you to wipe off spray and condensation without damaging the delicate lens surface.

PROTECTING WHEN TRAVELING

When traveling with your camera, use lens caps or covers to protect lenses. Store all small items and other accessories in cases and pack everything carefully so bangs and bumps won't cause them to hit each other. Be careful packing photographic equipment in soft luggage where it can be easily damaged. When flying, carry-on metal detectors are less damaging than the ones used to examine checked baggage. If in doubt, ask for hand inspection to reduce the possibility of X-ray induced damage.

STORING A CAMERA

Protect stored cameras from dust, heat, and humidity. A camera bag or case makes an excellent storage container. Remove batteries before storing.

Digital cameras have lots of components including batteries, chargers, cables, lens cleaners, and what not. It helps if you have some kind of storage bag in which to keep them all together.

D. Scanners—Photographing Photos

Although digital cameras are the most popular devices used to capture photos, scanners are still widely used to scan slides, negatives, and prints. You can do this yourself if you have a scanner, or you can have them scanned onto a CD disc or floppy at your local photofinisher or lab. The resolution of these images is often higher than you get from all but the most expensive cameras, so if quality is an issue this may be the best route to take.

SCANNING BASICS

Color scanners work, as cameras do, by creating separate red, green, and blue versions of the image, and then merging them together to create the final digital image. Some scan all of the colors in one pass while others take three passes, a slower but higher quality method. Which method is used depends on the scanner's image sensor. Most scanners use linear CCDs arranged in a row. Those that require three passes use a single row of photosites and pass different filters (red, green, or blue) in front of the sensor for each pass or use three different light sources. Other scanners use 3 rows of photosites, each row with its own filter so they can capture all three colors on a single pass.

As the image is scanned, a light source travels down the photo (some print and document scanners instead move the document past the light source). The light source reflects off a print or passes through a transparency and is focused onto the image sensor by a mirror and lens system. Because of this mirror and lens system, the sensor does not have to be as wide as the area being scanned.

The horizontal optical resolution of the scanner is determined by the number of photosites on its sensor. However, the vertical resolution is determined by the distance the paper or light source advances between scans. For example, a scanner with a resolution of 600 x 1200 has 600 photosites on its sensor and moves 1/1200 of an inch between each scan.

■ Some scanners are designed to scan photos and other documents, called *reflective copy*. Others are designed to scan slides and larger *transparencies*.

■ Most reflective scanners can scan 8½ by 11 originals but some can go much larger. Transparency scanners scan 35mm slides and negatives and some go much larger. As the size increases, so does the cost.

The true resolution of the scanned image depends on more than the scanner's resolution. It's ability to capture details is known as its *resolving power*. This resolving power is determined not just by resolution but also by the quality and alignment of it's lenses, mirrors, and other optical elements and the accuracy with which it moves along the image when scanning. It's possible for a very well designed scanner with a lower resolution to outperform a cheaper one with a higher resolution.

COLOR OR BIT DEPTH

Coming--most now seem to be 42 or 48 pixels.

DYNAMIC RANGE

Scenes in the real world are full of bright light and deep shadows. The extremes are referred to as the *dynamic range*. Film doesn't have anywhere near the dynamic range of nature, so it's always a struggle to accurately capture a scene on film. It's like trying to squeeze one of those coiled snakes back into the can after you've taken the lid off to let it pop out. Ansel Adams developed the System to expand and contract the dynamic range with black and white film, but color film can't be manipulated in the same way. When film is turned into prints, they have even less dynamic range so something is always lost. This is one of the reasons that it's better to scan slides or negatives then prints. Monitors have a dynamic range closer to slides than to prints. This means that when you scan images for the Web, you need to be sure you capture the full dynamic range.

How much dynamic range you can capture depends on the scanner's ability to register tonal values ranging from pure white to pure black. If the scanner doesn't have enough tonal range, details will be lost in shadow areas, highlights, or both.

A scanner's dynamic range can be measured and given a numeric value between 0.0 (white) to 4.0 (black) that indicates its ability to capture all values within the full dynamic range. Common flatbed scanners typically register values from about 0.0 to 2.4. New 30- or 36-bit scanners claim a dynamic range up to around 3.0, making them more adept at pulling detail out of shadow areas within images.

Although image density ranges from pure white to pure black, no detail can be seen in those areas. As you progress from pure white into slightly darker areas, detail emerges. The point at which a scanner can detect this detail is called DMin (minimum density). The same is true at the other end of the spectrum. The point at which detail can be detected before the image goes to pure black is called DMax (maximum density). The dynamic range is calculated by subtracting DMin from DMax. For example, if a scanner has a d-min of 0.2 and a d-max of 3.2, its dynamic range is 3.0.

FILM SCANNERS

Film scanner courtesy of Nikon.

The highest quality scans are from slides or negatives because they have a much higher dynamic range than prints. Special film scanners (also called slide or transparency scanners) have been designed to scan film and the results are outstanding. By using the included filmstrip holder, strips up to 6 frames in length can be scanned, one frame at a time. In fact, Photo CDs are created on high resolution film scanners such as these.

Because slides and negatives are so small and must be enlarged so much, these units must have very high resolutions to be really useful. Even at 2700 dpi, a print on a 1500 dpi printer would be less than 2 inches wide.

Some of the best film scanners use a software program called Digital ICE from Applied Science Fiction to eliminate dust and scratches on the surface of the scanned film.

FLATBED SCANNERS

Flatbed scanners are reflective scanners useful for scanning both black and white and color prints. Flatbeds are excellent for scanning old photographs for restoration purposes. (The print should be removed from any frame to make flat contact with the scanner glass. Make sure the glass on the flatbed is clean.)

One advantage of flatbed scanners is that they do double-duty. They are ideal for copying documents of all kinds and many even come with OCR (optical

Umax has a variety of scan frames that simplify scanning slides and transparencies, and help avoid newton rings.

character recognition) software that converts printed text to an editable digital form.

There are two primary image-capturing sensors used in flatbed and sheetfed scanners: the Charge Couple Device (CCD) and the Contact Image Sensor (CIS). Since scanners using a CCD required an elaborate lens and mirror optical system, there is lots that can go wrong if things get out of alignment. To simplify the system, and lower its costs, new CIS (contact image sensor) scanners use a single row of sensors that are in contact with the document being scanned. The document is illuminated by a row of red, blue, and green LEDs that mix to form white light. This design makes it possible to have very thin scanners but the image quality does not yet match CCD scanners.

When first encountering a copy machine, many people have tried copying money, photographs, and other objects. Some even go so far as to press their nose or other parts of their anatomy against the glass to capture an image. Basically, they are using the copier as a lensless camera. You can do the same with a flatbed scanner and the results can be interesting. One trick is to try different background materials laid on top of the objects to be scanned. These can range from another image to black velvet.

Many flatbed scanners come with optional transparency units that allow you to scan slides. A transparency adapter is a scanner cover that diffuses light evenly through the transparent media. It sits in place of the copyboard cover that is included with the scanner. Generally, the resolution of these units is below those of units designed to scan transparencies.

DRUM SCANNERS

When price is no object and quality is paramount, you need to have prints or transparencies scanned on a drum scanner. On these scanners the transparency or print is affixed to a glass drum. As the drum spins, the image is read a line at a time by a photomultiplier tube instead of a CCD. A bright pinpoint of light is focused on the image and its reflection (prints) or transmission (transparencies) is measured by the tube. These tubes provide the highest quality RGB and CMYK scans with greatly improved highlight and shadow detail. Their dynamic range is so high they can capture detail in both deep shadows and bright highlights and they also capture subtle differences in shading. Resolutions range up to 12,500 dpi and higher and these scanners have very large scanning areas. Drum scanners use liquid mounts to mask surface imperfections such as scratches. The liquid also minimizes rainbow colored Newton rings that form when film is placed against a polished drum.

Drum scanner courtesy of Fujifilm.

These expensive scanners are available at service bureaus where you pay by the scan. The cost of the scanner, computer time, and labor involved with a drum scan demands a higher charge.

E. Capturing Images in RAW Format

One of Ansel Adam's better know expressions, drawn from his early experiences as a concert pianist, was "The negative is the score, the print is the performance." In digital photography, the image file is your score and Photoshop or other photo-editing program is where you perform. The printer then just does what you've told it to do as you edited the image. To get the highest possible quality, you want to start with the best possible score—a RAW image file. These files contain all of the image data captured by the camera's image sensor without it being filtered or adjusted. You can interpret this data any way you want instead of having the camera do it for you. This format is so useful it's being offered on more and more digital cameras. If you want total control over exposure, white balance, and other settings, this is a format you will learn to love.

ADVANTAGES OF USING THE RAW FORMAT

There are a number of advantages to using the RAW format:

- RAW images aren't compressed using a lossy compression scheme that throws out data to make image files smaller. Although some cameras have a compressed RAW format, these images are compressed using lossless compression. When you open these images, they contain all of the original image data.

- RAW images aren't processed in the camera as JPEG images are. When you take JPEG photos, a processing chip with the power of a small computer manipulates them based on the camera settings you have used and then compresses them to reduce their size. The changes made to your images cannot be undone later because it's the final, altered image that is saved in the image file. Some of the original image data is lost for good. With RAW images, all of the original data captured by the camera is saved in the RAW image files and you process them later on your computer. The settings used to take RAW images are saved, but they are not permanently applied to your images until you save them in another format such as JPEG or TIFF. The images displayed on the screen when you use the camera's playback mode are just thumbnails.

- RAW images have greater bit depth and that gives you smoother gradations of tones and more colors. For example, JPEG images use only 8 bits per color (RGB) or 24 bits total. This means that JPEG images can have only 256 tones (2^8) and 16,777,216 colors (2^{24}). Meanwhile RAW images often use 16 bits per color or 48 bits total. This means images can have 65,536 tones (2^{16}) and 281,474,976,710,656 colors (2^{48}).

- RAW images can be processed again later when new and improved applications become available. Your final image isn't permanently altered by today's generation of photo-editing applications.

- You can create and save more than one version of the same RAW image. For example, one trick with RAW images is to adjust highlight and shadow areas separately so you have two versions of the same image that you then combine into one. By selectively erasing parts of the top image, areas of the lower image show through.

TIP

RAW image files can be identified by their extensions. For example:

- Canon is .CRW
- Nikon is .NEF
- Olympus is .ORF
- Sony is .SRF

DISADVANTAGES OF USING THE RAW FORMAT

Admittedly, there are drawbacks to using RAW images—the size of their files and the need process them before they can be viewed as anything other than thumbnails, e-mailed, posted on a Web site, printed or imported into another program to create a slide show or publication. When you are done shooting for the day, there is still work to do.

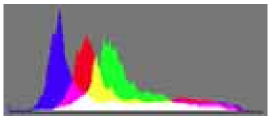
- RAW files in the camera are quite large. Even those that are compressed using lossless compression aren't compressed a great deal. However, TIFF, the alternative high-quality format offered on some cameras, creates even larger files—and they have also been processed by the camera. This size advantage of RAW over TIFF files diminishes when you process them on your computer since you normally save the processed images in PSD (Photoshop) or TIFF formats to retain their quality. As a result you often have large RAW and very large TIFF versions of the same images taking up room on your system. If you use this format a great deal you will need more storage space in the camera and computer and processing times will be longer.

- Since RAW images aren't processed in the camera, you have to process them on the computer and this takes time. Some cameras help you get around this by simultaneously capturing JPEG versions at the same time they capture RAW images. You can use these admittedly inferior, but more universally supported images, for many of your applications and reserve the high quality RAW versions for when you need the highest possible quality.

RAW IMAGE SOFTWARE

Since each camera company has defined its own proprietary RAW format, many operating systems and even photo-editing programs are unable to recognize some or all of these files. This is especially true now that so many camera companies are introducing RAW formats. Most software companies are behind the curve and it will be years before things stabilize and all RAW formats are recognized and supported by all operating systems and photo-editing applications. At the moment most photographers shooting RAW images view, process, and edit them in one of the following ways:

- Adobe publishes the Adobe® Camera Raw Plug-In for Photoshop 7 and Photoshop CS and Phase One publishes Capture One software in a number of versions. The Adobe plug-in is free and lets you view thumbnails of supported RAW image files with the File Browser and open them directly into Photoshop. You would probably only consider and purchase a less integrated application such as Phase One's if you aren't using one of the latest versions of Photoshop or you prefer the alternative program's features.



Photoshop's Camera Raw plug-in displays a histogram for each of the three colors—R, G and B.

- The camera manufacturer always supplies a program along with the camera. In some cases they also sell more powerful software. Typical of these programs are Nikon's Picture Project and Nikon Capture programs, Canon's File Viewer Utility, and Sony's Image Data Converter. There are also a number of other third-party programs that let you view RAW images and do at least some editing . However, since there are so many different RAW formats, not all are supported by all programs. Check to be sure your format is. Even some camera companies have used different RAW formats on different camera models.

In many cases, programs from camera companies are so limited that you can only make a few adjustments and then you have to save the image as a TIFF or JPEG image to open and edit it further with a photo-editing program. Not only is this two-step approach time consuming, you may loose some color

When you open most RAW image files with Photoshop, the Camera Raw dialog box opens with a preview of the image, a histogram, and controls you use to adjust the image.

depth in the process. Your camera may capture images using 16 bits per color and JPEG supports only 8 bits (although TIFF supports 16). If you do the math you'll see that converting 16 bit images to 8 bits reduces the number of tones from thousands to hundreds and the number of colors from trillions to millions. Since it's always better to adjust images at their greatest color depth, you need to make as many adjustments as possible before saving them in a format that doesn't support that depth.

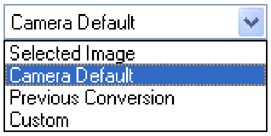
ADJUSTING RAW IMAGES

One writer (Charlotte Lowrie) calls RAW files "A second chance to get it right" because it's as if you are changing camera settings after you've taken the picture, not before. For example, when you shoot a JPEG image under fluorescent lights, the camera adjusts the image to remove the yellow-green tint. Any changes you make later are on top of this initial change. If you shoot the image in RAW format, the camera just captures the images as is and you decide what white balance setting to use later. You can even create different versions of an image, each with its own white balance. Since there are so many programs that edit RAW images, let's look at the most popular—Adobe's free Camera Raw Plug-in:

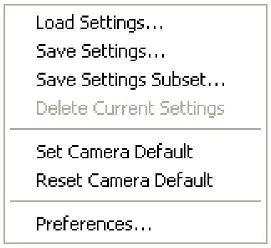
When using Photoshop CS or 7 with the plug-in installed, you can open RAW images just like any other image files, using the *File > Open* commands or the File Browser. The image opens in the Camera Raw dialog box, displaying a preview of the image and controls you use to make adjustments. On the right side of the screen are two tabbed settings pages—*Adjust* and *Detail*. Two more are displayed if you click the *Advanced* radio button—*Lens* and *Calibrate*. It's on these tabbed pages that you make most adjustments. Your choices include the following starting with the *Adjust* page:

- *Color* is adjusted with a drop down menu and two sliders—*Temperature* and *Tint* used to remove any color casts in the image.
- *Tonal adjustments* are made using five sliders that adjust exposure, shadows, brightness, contrast, and saturation.

Adobe's Camera RAW dialog box settings tabs.



The Settings drop-down menu choices.



The Camera Raw plug-in's menu.

TIP

Photoshop does save files in a RAW format but it's different from camera RAW formats and is used to transfer images between applications and computer platforms.

- The *Detail* tab's sliders adjust sharpness, luminance smoothing, and color noise reduction.
- The *Lens* tab's sliders compensate for any chromatic aberration or vignetting caused by the camera.
- The *Calibrate* tab's sliders correct a color cast in the shadows and adjust the built-in profile to alter the rendering of non-neutral colors.

When you first open a raw image file with Photoshop's Camera Raw plug-in, the settings used to take it are stored in a central database file (the default) or a separate stand-alone file called a sidecar file, with the extension XMP. (Sidecar files are best if you are burning images to CD/DVDs, sharing them with others, or editing them on more than one machine.) These stored settings let you return the image to its original state at any point. As you change settings, they are also stored in one of the two locations so you can use them later, or even use them with other images that need the same procedures. The important thing to understand about RAW images is that the original image is never altered. Any changes you make are saved as instructions, and then applied only when the RAW file is saved in another format.

After making adjustments to a RAW file in the Camera Raw dialog box, you click *OK* to open a copy of the camera raw image in Photoshop with the Photoshop Camera Raw plug-in settings applied to it. You can then edit the image further before saving the finished image in a Photoshop-supported format. In most cases you would save it as a PSD (Photoshop) or TIFF file to preserve the highest possible quality, but you may also want to save images in the JPEG format because their files are smaller.

Since changes are not applied to the original image, but are stored in a database or sidecar file, all original image data is always preserved. The next time you open the original RAW file in the Camera Raw dialog box, the *Settings* drop-down menu lets you display it the way it came from the camera (*Camera Default*), use the last changes you made on another image (*Previous Conversion*), or apply the settings made to one image to others (*Selected Image*). When you have shot a number of images under the same conditions, you can also apply the changes you have made to one image to another image or a group of images by clicking the arrowhead next to *Settings*. The Camera Raw plug-in menu is displayed listing commands to *Load Settings*, *Save Settings*, and so on that lets you do so.

A RAW image before processing (above) and after (right).