



Health

- Coffee
- Cooking Tips
- Recipes & Food and Drink
- Wine & Spirits
- Elder Care
- Babies & Toddler
- Pregnancy
- Acne
- Aerobics & Cardio
- Alternative Medicine
- Beauty Tips
- Depression
- Diabetes
- Exercise & Fitness
- Hair Loss
- Medicine
- Meditation
- Muscle Building & Bodybuilding
- Nutrition
- Nutritional Supplements
- Weight Loss
- Yoga
- Martial Arts
- Finding Happiness
- Inspirational
- Breast Cancer
- Mesothelioma & Cancer
- Fitness Equipment
- Nutritional Supplements
- Weight Loss



Internet

- Affiliate Revenue
- Blogging, RSS & Feeds
- Domain Name
- E-Book
- E-commerce
- Email Marketing
- Ezine Marketing
- Ezine Publishing
- Forums & Boards
- Internet Marketing
- Online Auction
- Search Engine Optimization
- Spam Blocking
- Streaming Audio & Online
- Music
- Traffic Building
- Video Streaming
- Web Design
- Web Development
- Web Hosting
- Web Site Promotion
- Broadband Internet
- VOIP
- Computer Hardware
- Data Recovery & Backup
- Internet Security
- Software



Business

- Advertising
- Branding
- Business Management
- Business Ethics
- Careers, Jobs & Employment
- Customer Service
- Marketing
- Networking
- Network Marketing
- Pay-Per-Click Advertising
- Presentation
- Public Relations
- Sales
- Sales Management
- Sales Telemarketing
- Sales Training
- Small Business
- Strategic Planning
- Entrepreneur
- Negotiation Tips
- Team Building
- Top Quick Tips
- Book Marketing
- Leadership
- Positive Attitude Tips
- Goal Setting
- Innovation
- Success
- Time Management
- Public Speaking
- Get Organized - Organization



Finances

- Credit
- Currency Trading
- Debt Consolidation
- Debt Relief
- Loan
- Insurance
- Investing
- Mortgage Refinance
- Personal Finance
- Real Estate
- Taxes
- Stocks & Mutual Fund
- Structured Settlements
- Leases & Leasing
- Wealth Building
- Home Security



Entertainment

- Mobile & Cell Phone
- Video Conferencing
- Satellite TV
- Dating
- Relationships
- Game
- Casino & Gambling
- Humor & Entertainment
- Music & MP3
- Photography
- Golf
- Attraction
- Motorcycle
- Fashion & Style
- Crafts & Hobbies
- Home Improvement
- Interior Design & Decorating
- Landscaping & Gardening
- Pets
- Marriage & Wedding
- Holiday
- Fishing
- Aviation & Flying
- Cruising & Sailing
- Outdoors
- Vacation Rental



Education

- Book Reviews
- College & University
- Psychology
- Science Articles
- Religion
- Personal Technology
- Humanities
- Language
- Philosophy
- Poetry
- Book Reviews
- Medicine
- Coaching
- Creativity
- Dealing with Grief & Loss
- Motivation
- Spirituality
- Stress Management
- Article Writing
- Writing
- Political
- Copywriting
- Parenting
- Divorce

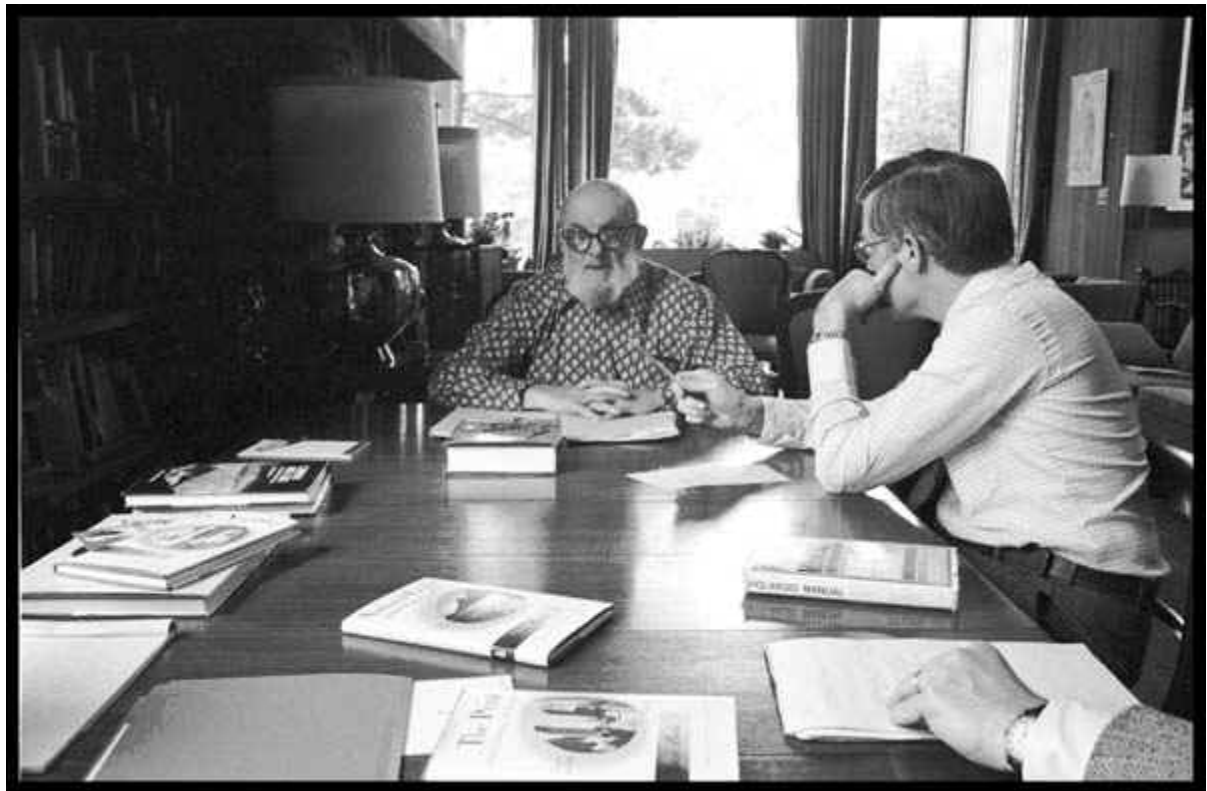
Digital Photography



Dennis P. Curtin

PREFACE

Photography has become pervasive in our society. Each of us sees hundreds, if not thousands, of images every day. The vast majority of images are those taken for personal enjoyment. These images either capture the moment or provide a form of self-expression. Many other images are used to lubricate the wheels of commerce. They appear in ads and on magazine covers and packages. Other images in magazines and newspapers are used to convey news or to make an editorial point. No matter what purpose images are put to, it is the images themselves that are transcendent. The way they have been captured is secondary. However, changes in technology can open new opportunities and approaches that change the way images look. For example, the introduction of the 35mm Leica back in the 1930s made it easier to capture fast moving action and images became more spontaneous and fluid, a far cry from the more formally posed images required by much larger and more awkward cameras.



This book is dedicated to Ansel Adams who had the kindness to introduce a young editor to the exciting world of photography.

The vast majority of the images you see are still captured with traditional cameras and film. However, this is changing rapidly as digital cameras are accepted in more and more areas of photography. Already they have made major inroads into catalog photography and photojournalism. They are now well on their way to becoming a major factor in photography for self-expression. In time, they are destined to dominate photography.

Although photographic technology has changed dramatically since its invention in 1840, the principles of good images have remained fairly constant. The images taken in 1840 by Henry Fox Talbot and Daguarre are as well composed and interesting as any images taken with the most modern equipment. However, although technology doesn't make good images any easier

to capture, it has made profound changes in others areas of photography. Digital photography in particular has made it possible to capture an image and then instantly distribute it around the world. Digital photography has also closed the darkroom and opened up an entirely new way to edit and present images. A digital camera, a notebook computer, and a high-speed Internet connection makes each of us a node on an ever-expanding network of photographers and viewers.

In this on-line book we explore photography in a very traditional way, but the emphasis is on modern technology from digital cameras, to digital darkrooms, to on-line publishing and sharing of images.

This text provides an introduction to all aspects of the emerging world of digital photography. Starting with the camera and image capture, it then goes on to discuss image storage, transfer, editing, printing, and distribution. As you follow the path through the book you'll learn much about hardware, software, and procedures.

In many ways teaching digital photography is much like teaching traditional photography. But this is true only up to a point. In traditional courses the end result is usually a print and the darkroom experience of creating it. In digital photography courses, a print is only one of many possible applications of a captured image. In many ways it's the least exciting aspect to students who are more oriented to the Internet and the possibilities it opens up to displaying and sharing images world-wide. It's this community aspect of digital photography that draws many students into courses they might not otherwise have taken.

As a teacher, the digital approach also makes it easier to demonstrate techniques and procedures on a one-to-one basis. A student who can preview results immediately can grasp ideas such as exposure compensation much easier and faster than a student who works in traditional media. It's this immediate feedback that shows students how the principles they are learning apply in situations of all kinds.

INTRODUCTION



0.1 WHY GO DIGITAL?

Once captured, digital photographs are already in a universal format that makes them incredibly easy to distribute and use. For example, you can insert digital photographs into word processing documents, send them by e-mail to friends, or post them on a Web site where anyone in the world can see them. With many cameras you can immediately see your images on a small LCD screen on the back of the camera, or you can connect the camera to a TV and show them much like a slide show. Some cameras can even be connected to a microscope or telescope to display dramatically enlarged images on a large-screen TV. Digital photography is instant photography without the film costs!



A small digital camera is easy to carry so you'll have it when you see things you never expected to see.

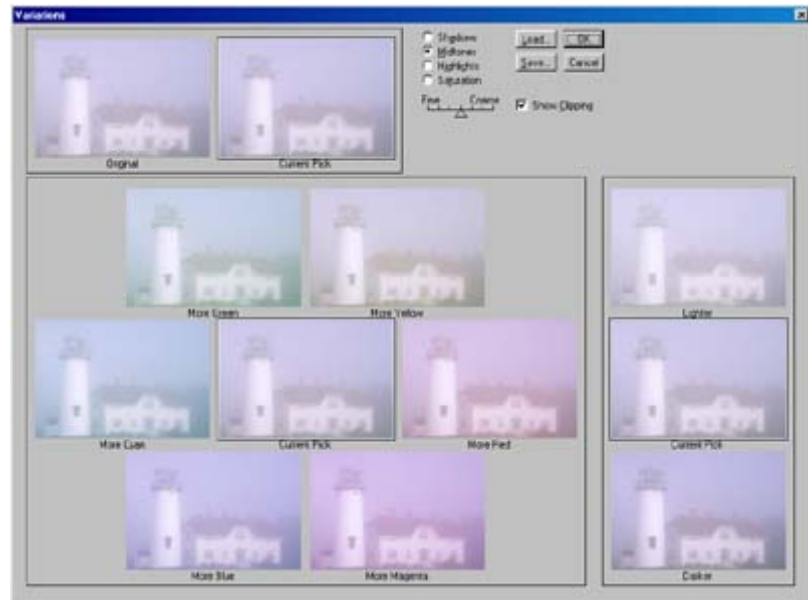
In addition to distributing and displaying photographs, you can also use a photo-editing program such as Photoshop to improve or alter them. For example, you can crop them, remove red-eye, change colors or contrast, and even add and delete elements. It's like having a darkroom with the lights on and without the chemicals.

If you're considering going digital, here are a few more reasons to get even more serious.

- Going digital saves you money in the long run by not buying rolls of film and paying for their development.
- Digital cameras instantly show you how your pictures look so you'll no longer have those disappointments a day or two later when your film is processed.

- You can view images before printing them. If you don't like what you see, edit them the way you want them or delete them.
- Digital photography doesn't use the toxic chemicals that often end up flowing down the drain and into our streams, rivers, and lakes.
- No more waiting to finish a roll before processing it. (Or wasting unexposed film when you can't wait.)

Once you've captured an image in digital format, you can easily distribute, organize, store, and enhance it.



Digital cameras are becoming more than just cameras. Some digital cameras are capable of capturing not only still photographs, but also sound and even video—they are becoming more like multimedia recorders than pure cameras.

Free Photography, Photographic Freedom

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 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.



A mule carries William Henry Jackson's photographic outfit. Courtesy of the [Library of Congress](#).

0.2 THE THREE STEPS OF DIGITAL PHOTOGRAPHY

Digital cameras are just one link in a long chain leading from the original scene through to the final image that you display or distribute. In fact, a digital camera isn't even an absolutely necessary link in the chain. The key element in digital photography is an image in a digital format made up of pixels. Although a digital camera captures photos in this digital format, you can also scan slides, negatives, or prints to convert these traditional images into the same digital format.



To understand how the camera fits in with other parts of the digital photography system, it helps to understand the three basic steps involved in creating and using digital photographs—input, processing, and output.

*Image
processing
steps.*



Step 1. Inputting Photographs

Input devices get photographs or other data into a computer system. The input device you're probably most familiar with is the keyboard. However, there are hundreds of other input devices including mice, touch pads, voice recognition systems, scanners, and so on. Here are some of the input devices you can use to create digital photographs:

- Digital still cameras capture photographs in a digital format.
- Film cameras capture photographs on slides, negatives, or prints which you can then scan to convert them to digital photographs.
- Video cameras capture images in a video format. You can then use a frame grabber to isolate out individual frames and save them as still images.
- Digital video cameras sometimes are able to capture still images just like a digital still camera does. You can also use a video-editing card to extract still images from the digital video.



*Digital cameras are the easiest way to get images in a digital format because there is no conversion process required.
Courtesy of [Olympus](#).*

Step 2. Processing Photographs

Once a photograph is in digital form, you can store it on your system and then edit or manipulate it with a photo-editing program such as Photoshop. The things you can do to a digital image are almost endless. In some cases you improve an image by eliminating or reducing its flaws. In other cases, you adjust an image for other purposes, perhaps to make it smaller for e-mailing or posting on a Web site. Finally, you might take an image to a new place, making it something it never was. Here are just a few of the ways you can process images:

- Crop the photograph to emphasize the key part.
- Reduce the size of the photograph to make it smaller for posting on the Web or e-mailing.
- Use filters to sharpen it or even make it look like a watercolor or oil painting.
- Stitch together multiple frames to create panoramas.
- Merge two images to create a 3D stereo effect, or an animated image for display on the Web.
- Change brightness and contrast to improve the image.
- Cut and paste parts of one image into another to create a photo montage.
- Convert the photograph to another format.



The original photo, taken with a digital camera.



The image manipulated by Cyndi Kirkpatrick at [Eos Development](#).

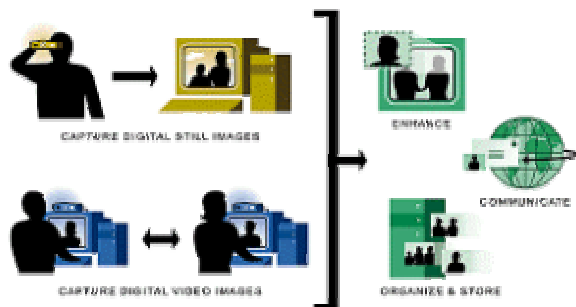
Step 3. Outputting Photographs

Once an image is the way you want it, you can output it to share with others. There are lots of ways to display and distribute digital photographs. Here are some of the most popular ways:

- Print the image on a color printer.
- Insert the photograph into a word processing or desktop publishing document.
- Post the photograph on a Web site or a photo network.
- E-mail the photograph to friends or family members.
- Send the photo to a service on the Web for specialty printing onto T-shirts, posters, key rings, mouse pads, even cakes and cookies.
- Store the photograph on your system for later use.
- Use a film recorder to convert the photograph into a slide that you can project with a slide projector.

0.3 THE WORLD OF DIGITAL PHOTOGRAPHY

Digital photography is a new way to capture photos using a solid-state image sensor instead of traditional film. Once captured, the photos are then stored in a universal digital format that lets you move them to a computer, print them on a printer, view them on a television, e-mail them to friends, or even put them on the Web where anyone in the world can see them. Digital photography is becoming increasingly popular because of the flexibility it gives you when you want to use or distribute an image.



Once you've captured an image in digital format, you can easily enhance, distribute, or organize and store it. Courtesy of [Intel](#).

It's both the immediacy and flexibility of digital imaging that's made it so popular in so many areas. However, there is one aspect of digital photography that is rarely mentioned. This is the new freedom it gives you to explore photography. In the 1870's when William Henry Jackson was carrying 20 x 24 glass plates around the West on a mule, you can believe he hesitated before he took a photograph. We may not be carrying 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 in the familiar rut that's delivered for us in the past. Surprisingly, Jackson had one big advantage we've lost over the last century. If an image didn't turn out, or if he was out of glass plates, he could just scrape off the emulsion from an image he was willing to sacrifice, recoat the plate, and try again. Digital photography not only eliminates that nagging "is it worth it?" question but 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 images. You may be surprised at the images you get if you exploit this new era of uninhibited shooting.

Perhaps Not the Best Place to Start

People like [David Grenewetzki](#) think nothing of strapping their new digital camera to a remote control airplane, or even a rocket, and launching it into the wild blue yonder to capture photos with a bird's-eye view. Until camera prices come way down, you might want to find other applications for your new camera.



What could be more fun than strapping your new camera onto a remote control airplane for pictures from hundreds of feet up! Check out David's site for lots more on this and rockets too. Image © 1997-1998 by [David Grenewetzki](#).

Journals

Most of us take lots of photos and then chuck them in a drawer. If we care enough about some, we may even put them in an album. The problem is, we rarely share them with others and after awhile forget a lot about the circumstances under which we took them. Digital images change all of that. They are easy to insert into documents or Web pages along with captions or text. This makes it easy to create journals for personal memories or to share with others. You can post them on the Web for anyone to see, or print copies and give them to people who shared the experiences with you. Everyone can now be a publisher.

Street Photography

There is a grand tradition of photographing on the street, capturing the fast action as it unfurls. This style of photography grew out of the freedom first offered by the 35 mm Leica, the first camera to truly allow high quality photography on the fly. Previously, cameras were tethered to tripods, or bulky and obvious. Bring up a one of those big, boxy Graflexs, and people ducked or fled the scene. Bring up a Leica and no one notices, not even when it makes its muffled "click." Digital cameras are often even smaller than the Leica and make no sound at all.



These models in a London store window seemed quite willing to be photographed. Overcoming my usual shyness, I fired away.

Nature

Nature photography is perhaps one of the most difficult kinds of photography. Subjects are elusive; one reason why so many "nature" photographs are taken in zoos and preserves. There it's like shooting fish in a barrel. However, if you do it au natural, nature photography joyfully merges a love of the outdoors with a love of making images. If no good shots appear, you've still had a nice walk.



I stalked these big-horned sheep through the wilds of the London Zoo.

Travel

One the first and most lasting applications of photography has been to bring distant worlds home to viewers. Digital photography now makes it possible to put all of your images on the Web and bore the entire world instead of just your friends and family. (I am probably the only photographer who fell asleep while showing his own slides.)



Stonehenge sits alone on England's Salisbury Plain looking much like it must have to those who built it thousands of years ago.

Journalism

Reporters and news organizations such as the Associated Press have adopted digital cameras because the photos can be immediately transmitted from the site where they're taken over telephone lines or even a wireless connection. And once received, they are ready to use, no lab processing is required. A photo of the winning touchdown at a Super Bowl game can appear in a paper across the country within minutes. The low-resolution of digital cameras (compared to silver-based film) doesn't matter because newspaper printing is also low-resolution. Good sites on digital photojournalism are [Rob Galbraith's](#) and [Dirck Halstead's](#).



A rescue helicopter approaches the cliffs of Dover, England and rescues a man stranded by the incoming tide.

Multimedia

Some big users of digital images are multimedia developers. Since multimedia is always displayed on a computer screen, or projected from it, digital images are a necessary ingredient. Whether originally taken with a digital camera or with a film camera and then scanned, the final image has to be in a digital format.



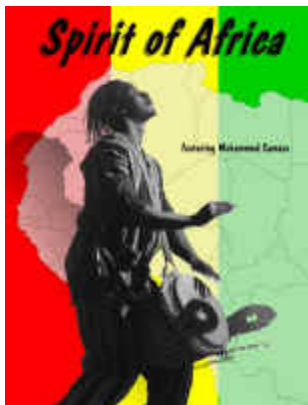
The PACE program was produced by Kim Foley to accompany a college computer text written by herself, Kunal Sen, Cathy Morin and myself. The text and program are published by Irwin/McGraw-Hill.

Law Enforcement

Wegee may not have put down his flash-bulb equipped Grapflex for a digital camera, but law enforcement agencies sure have. Like others, they are attracted to the speed of processing and the ability to easily enhance images and distribute them on-line.

Graphic Illustration

Posters, books, magazines, journals, reports, and other kinds of other documents are illustrated with photographs and other images. Since these publications are increasingly desktop published, digital photos are just another part of the stew.



Rick Ashley took a digital photograph of the drummer Mohammed Camara and merged it with some clip art to create a stunning poster used to announce classes and performances. Image courtesy of [Rick Ashley](#).

Insurance

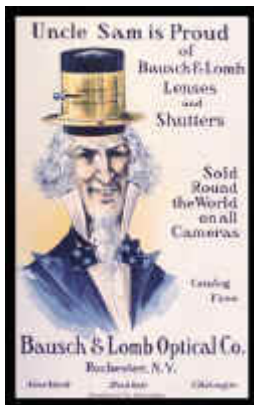
If your house or office burns down, or blows or floats away, how do you prove you lost that velvet painting of Elvis? The best way is to photograph your belongings and store the image files on a disk. Then, hope you'll be able to open the images a decade from now when you need them and file formats and devices have changed (remember the 5 1/4-inch floppy?) To be on the safe side, display the images on the TV and tape them then store the tape in a safe place.



This historic old sign hangs on our kitchen wall. God forbid, the house burns down, you can now make a claim for it since you have its picture.

Copying

It's often necessary to make photographic copies of documents and objects. For example, a museum might want an illustrated inventory of everything in its possession. Digital cameras are ideal for this application.



Here an old advertisement for camera lenses has been copied.

Lots of us have old family photographs that have been tossed in drawers and not well cared for over the years. As our families grow and spread out, it's harder and harder to organize and share these images that recall so much. However having them scanned, or even just photographing them with a digital camera, makes them easy to insert into documents or e-mail.

Catalog Photography

Some of the early adopters of high-end digital cameras were photographers doing studio photographs for catalogs and other publications. They were able to quickly adopt these cameras for a variety of reasons. To begin with, objects such as bird houses or dinner plates don't move. This makes it possible to get the long exposures required by some high-resolution cameras that take three exposures to get a full color image. Another reason is that the images are usually reproduced small enough so their faults don't show. Finally, the production houses that prepare the catalogs prefer to receive digital images so they can avoid the time and cost of scanning them.



This studio image was taken with Sound Vision's CMOS-PRO – the first CMOS digital camera specifically designed for the graphic arts professional. Image courtesy of [Sound Vision Inc.](#)

Commercial Photography

Commercial photographers were amongst the first to adopt digital photography. Using expensive digital backs to large format cameras, these photographers are turning out images that rival those from film-based cameras.



Mike Berceanu shot this image on the Agfa StudioCam scanning digital camera. Courtesy of [Mike Berceanu](#).

Composite Imaging

Once images are in digital form, you can start to take pieces from various images and paste them into other images. These composite images can be tame or wild. In fact, compositing is done so often on television and in print advertisement that we're growing used to it.



Here the moon has been cut out of one image and pasted into another. You can't even tell the image has been altered.

Print Publishing

Once images are in a digital format, you can include them in desktop published documents created with programs such as Microsoft Word, PageMaker, or QuarkXPress.



Images have been placed in a PageMaker document to prepare them for publishing.

Web Publishing

Anyone who is taking photographs for the Web prefers digital cameras because the images are ready to post as soon as they are taken. The images don't have to be first processed and then scanned as film has to be. This saves both time and money. Since most screens display only low-resolution images, the low-resolution of some cameras is no drawback. In fact, higher resolution images would be too big to post on most Web sites and would have to be reduced anyway.



The author of this site has a number of Web sites all well illustrated with digital images. The site shown here is one for kids on [bulldozers](#) and other construction equipment. If you click the link to check it out, please come back.

Badges, Buttons, and Business Cards

Once the almost exclusive domain of Polaroid instant cameras, photos for IDs are increasingly taken in digital form. Once captured, they can be immediately printed right on the ID cards, making counterfeiting more difficult. You can also use the images to create buttons or illustrated business cards.



Fargo printers are used to make full-color ID cards complete with photographs. Courtesy of [Fargo](#).

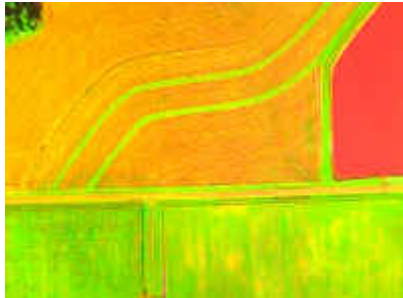
Newsletters

Newsletters from companies and organizations are often full of images. Employees and

members are honored when promoted, retired, or when they reach some milestone, and events are documented. As the publishing process has become digital and moved to the desktop, so have the photographs used to illustrate these newsletters.

Science

Digital photography is ideal for many scientific applications. Here a special digital camera has captured the spectral reflectance properties of plants so their status can be determined. Using photographs such as these, farmers are better able to manage their crops.



Digital cameras can also be used for special purposes. Here's an image taken with the Dycam ADC camera. And who ever said there wasn't art in science? I'd love to see what creative photographers could do with this camera. Courtesy of [Dycam](#).

Astronomy

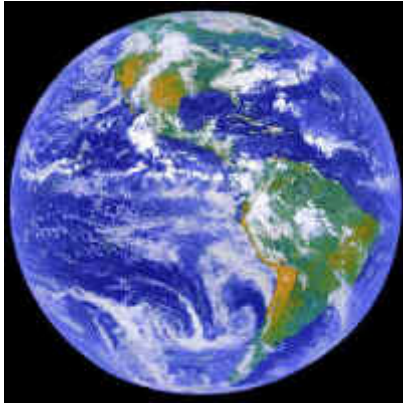
Digital image sensors have been used in astronomy for years. They are now widely used in place of film, even on the orbiting Hubble Space Telescope.



This NASA Hubble Space Telescope image shows one of the most complex planetary nebulae ever seen, NGC 6543, nicknamed the "Cat's Eye Nebula." Hubble reveals surprisingly intricate structures including concentric gas shells, jets of high-speed gas and unusual shock-induced knots of gas. Estimated to be 1,000 years old, the nebula is a visual "fossil record" of the dynamics and late evolution of a dying star. This image was created with support to Space Telescope Science Institute, operated by the Association of Universities for Research in Astronomy, Inc., from NASA contract NAS5-26555 and is reproduced with permission from [AURA/STScI](#).

Space Exploration

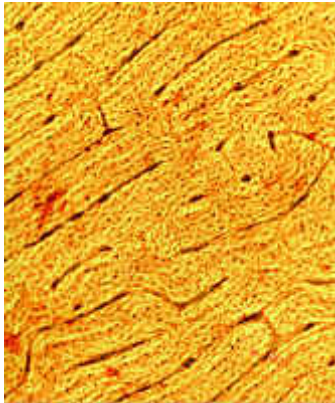
When you fly a camera through space or land it on another planet, getting film back to Earth is a big problem. The solution, of course, is to use a digital camera and send the image back digitally by radio transmission. That's exactly what was done on the Mars Rover mission where a small vehicle crawled across the surface of the planet sending back images—some of them in stereo.



Full view of the Earth, taken by GOES-8 (Geostationary Operational Environmental Satellite) on 2 September 1994 at 18:00 UT. Courtesy of [Public Use of Remote Data](#).

Microscopy

It's common practice to take videos or photographs of what's revealed by a microscope. One of the masters of this was Roman Vishniac who was a true scientific artist. Digital cameras are ideal for this situation because the images can be immediately displayed.



Normal human bone captured through a Nikon microscope with SoundVision's CMOS-PRO. Image courtesy of [Sound Vision, Inc.](#)

Fine Art

Fine art photography is a broad category that has included everything from the amazing prints of Ansel Adams to fuzzy prints from a pinhole camera. It's not at all surprising that digital cameras have become part of the hardware repertoire that artists work with. Long before Jerry Uelsmann was making montages, this form of photography was going on. Here is a 1905 image by Adelaide Hanscom that has many of the features we see in manipulated digital art.



Adalaide Hanscom did an entire series of manipulated images to illustrate a 1905 edition of the Rubiyat.

Real Estate

Realtors are big consumers of photography. Exterior shots are taken for newspaper ads and interior shots for brochures and Web sites. The ease and immediacy of digital cameras makes them widely used in this field.



A typical interior view such as those taken for real estate brochures.

Fun

Photographs don't always have to be put to work. Most are really just for enjoyment. Capturing memories and strange sights are just a few such uses.



Peggy Curtin took this photo of a miniature St. Paul's Cathedral while leading a tour of Prince Edward Island in Canada.

Toys

With the recent development of low-cost image sensors that are used in cameras, companies are developing more products that include vision. Cameras can now go into products in which they were previously too expensive or bulky.

Nintendo offers a black and white camera that attaches to a Game Boy and a paint program you can use to manipulate the images—even stitch together panoramas from a series of shots. You can then use an accompanying printer to print the images on stickers.



The Game Boy camera lens rotates 360 degrees so you can take self portraits. Courtesy of [Nintendo](#)



The Barbie Photo Designer Digital Camera brings low-cost digital imaging to kids. Courtesy of [Mattel Media](#).

CHAPTER 1, WHAT IS DIGITAL PHOTOGRAPHY



Objectives

- Be able to describe a digital image and the pixels from which it's made
- Explain how the number of pixels in an image affects its size
- Explain why enlarging an image past a certain point reveals the pixels from which it's made

Introduction

Digital cameras and traditional cameras are very much alike in many respects. The biggest difference is the way images are captured. With traditional films, they are captured on silver-based film. With digital cameras, they are captured on solid-state devices called image sensors. In this chapter we take a look at the digital photograph and the image sensor used to capture it.

1.1 WHAT IS A DIGITAL PHOTOGRAPH?

This book is about digital cameras and the photographs they capture. Understanding the end product, the digital photograph, is a good place to begin understanding the entire digital photography process.

Pixels—Dots are all There Are

Digital photographs are made up of tiny squares 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 or printed page into a grid containing hundreds of thousands or millions of pixels. The computer or printer then uses the values stored in the digital photograph's file to specify the brightness and color of each pixel in this grid—a form of painting by number. Controlling, or addressing a grid of individual pixels in this way is called **bit mapping** and digital images are called **bit-maps**.

This reproduction of Grant Wood's famous painting "American Gothic" 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. Image courtesy of [Herman Goelitz Candy Company, Inc.](#) Makers of Jelly Belly jelly beans.

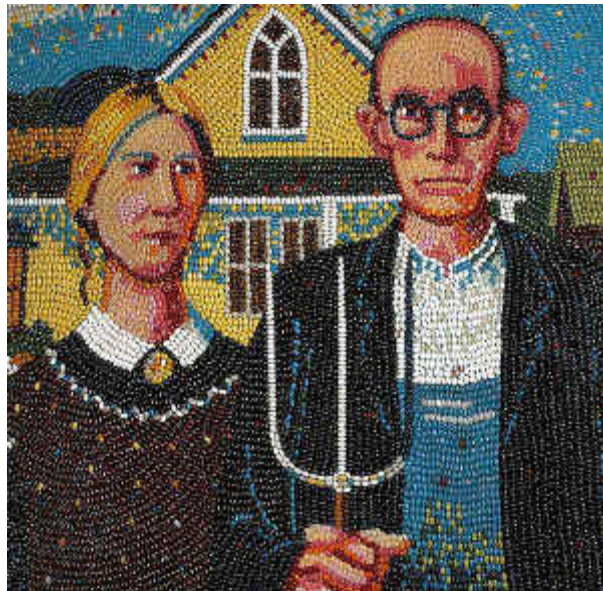


Image Size and Number of Pixels

The quality of a digital image, whether printed or displayed on a screen, depends in part on the number of pixels used to create the image (sometimes referred to as **resolution**). More pixels add detail to an image, sharpen edges, and increase resolution.

If you enlarge any digital image enough, the pixels will 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.

When a digital image is displayed at the correct size for the number of pixels it contains, it looks like a normal photograph.



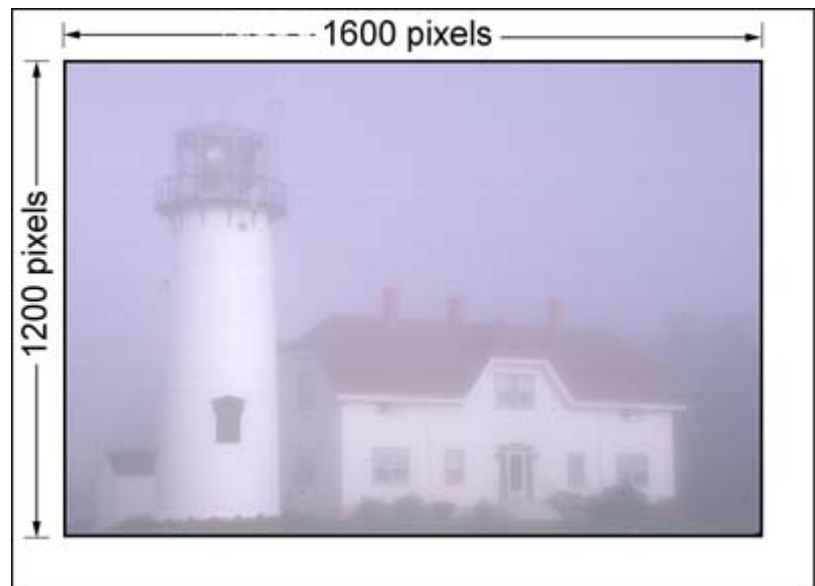
When an image is enlarged too much, its square pixels begin to show. Each pixel is a small square made up of a single color.



Describing Image Sizes

The size of a digital photograph 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 1600×1200 pixels (where " \times " is pronounced "by" as in "1600 by 1200"), or to contain 1.92 million pixels (1600 multiplied by 1200).

Image sizes are expressed as dimensions in pixels (1600×1200) or by the total number of pixels (1,920,000).



1.2 DIGITAL FILM—THE IMAGE SENSOR

Unlike traditional cameras that use film to store an image, digital cameras use a solid-state device called an **image sensor**. These fingernail-sized silicon chips now contain millions of photosensitive diodes called **photosites**. Each of these photosites records the intensity or brightness of the light that falls on it. Each photosite reacts to the light that falls on it by accumulating a charge; the more light, the higher the charge. The brightness recorded by each photosite is then stored as a set of numbers that can then be used to set the color and brightness of dots on the screen or ink on the printed page to reconstruct the image. Here we'll look closely at this process because it's the foundation of everything that follows.

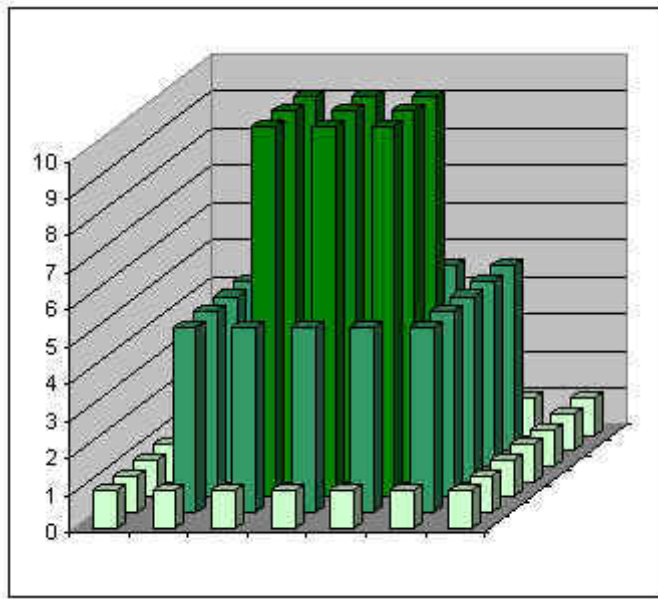


Image sensors contain a grid of photosites that convert light shining on them to electrical charges. These charges can then be measured and converted into digital numbers that indicate how much light hit each site. Courtesy of [IBM](#).

Just as in a traditional camera, light enters a digital camera through a lens. Digital cameras have one of three types of shutters that control how long light is allowed to enter and hence how dark or light the image is:

- **Electronically shuttered sensors** use the image sensor itself to set the exposure time. A timing circuit tells it when to start and stop the exposure
- **Electromechanical shutters** are mechanical devices that are controlled electronically.
- **Electro-optical shutters** are electronically driven devices in front of the image sensor which change the optical path transmittance.

*When the exposure is completed, the sensor is like a checkerboard, with different numbers of checkers (electrons) piled on each square (photosite). When the image is read off the sensor, the stored electrons are converted to a series of analog charges which are then converted to digital values by an **Analog-to-Digital (A to D) converter**.*



Color Depth

Color depth refers to how many bits are used to record each color. The more bits used, the richer the colors will appear. Most affordable cameras offer 24-bit color depths (8 bits for red, 8 for green, and 8 for blue), although 30-bit models exist (The Canon Pro70 was the first 30-bit consumer camera) and even this number can be expected to increase. Professional applications often require 36-bit color depth, a level achieved only by professional-level digital cameras. The more bits that are assigned to each color, the more gradations can be stored. For example, 8 bits let's you store 256 shades (2^8), 10 bits let's you store 1024 (2^{10}), and 12 bits let's you store 4096 (2^{12}). Combining the three colors captured in 8, 10, or 12 bits gives you a final full-color image is 24, 30, or 36 bit color. (This is discussed in more detail in [Topic 1.7 Image Color](#).)

Image Size

Most consumer cameras costing under a thousand dollars have pixel counts of about 2 million pixels. From these cameras, you can make good quality prints up to about 8 x 10 inches. Lower resolutions are fine for Web publishing, e-mail attachments, small prints, or images in documents and presentations. For these uses, higher resolutions just increase file sizes without significantly improving the image.

Aspect Ratios

They even have different aspect ratios—the ratio of image height to width. The ratio of a square is 1:1 and that of 35mm film is 1.5:1. Most image sensors fall in between these extremes. Some cameras have one aspect ratio for the image sensor and another for the viewfinder. This means you don't see the entire scene that will be captured when you take a picture.

Image	Width x Height	Aspect Ratio
35 mm film	36 x 24 mm	1.50
Display monitor	1024 x 768 pixels 800 x 600 640 x 480	1.33
Nikon 950	1600 x 1200 pixels	1.33
Photo paper	4 x 6 inches	1.50
Photo paper	8 x 10 inches	1.29
HDTV	16 x 9	1.80
Stationary	8 1/2 x 11	1.29



When an image has a different aspect ratio than the device it's displayed or printed on, it has to be resized to fit.

To calculate the aspect ratio of any image sensor, divide the largest number in its resolution by the smallest number. For example, if a sensor has a resolution of 1800 x 1600, divide 1800 by 1600. In this case the aspect ratio is 1.33, different from 35mm film.

Sensitivity

The speed, or sensitivity, of a silver-based film is given as an **ISO** (International Organization for Standardization) number that appears on the film package. The higher the number the "faster" or more sensitive the film is to light. If you've purchased film, you're already familiar with speeds such as 100, 200, or 400. Each doubling of the ISO number indicates a doubling in film speed so each of these films is twice as fast as the next fastest.

Image sensors are also rated using equivalent ISO numbers. Just as with film, an image sensor with a lower ISO needs more light for a good exposure than one with a higher ISO. Higher ISOs enhance freezing motion and shooting in low-light. All things being equal, it's better to get an image sensor with a higher ISO. Typically, ISOs range from 100 (fairly slow) to 3200 or higher (very fast).

Some cameras have more than one ISO rating. In low-light situations, you can increase the sensor's ISO by amplifying the image sensor's signal more (increasing its **gain**). Some cameras even increase the gain automatically. This not only increases the sensor's sensitivity, it also increases the noise; the equivalent of grain in a traditional silver-based image.

Image Quality

The image sensor in your camera has an impact on the images you take. All film cameras are just dark boxes into which you can insert any kind of film you want. It's the film you choose that gives photographs distinctive colors and tones. If you think one film gives images that are too blue or red, you can change to another film. With digital cameras, the "film" is permanently part of the camera so buying a digital camera is in part like selecting a film to use. Like film, different image sensors render colors differently, have different amounts of "grain," different sensitivities to light, and so on.

1.3 CAPTURING AN IMAGE

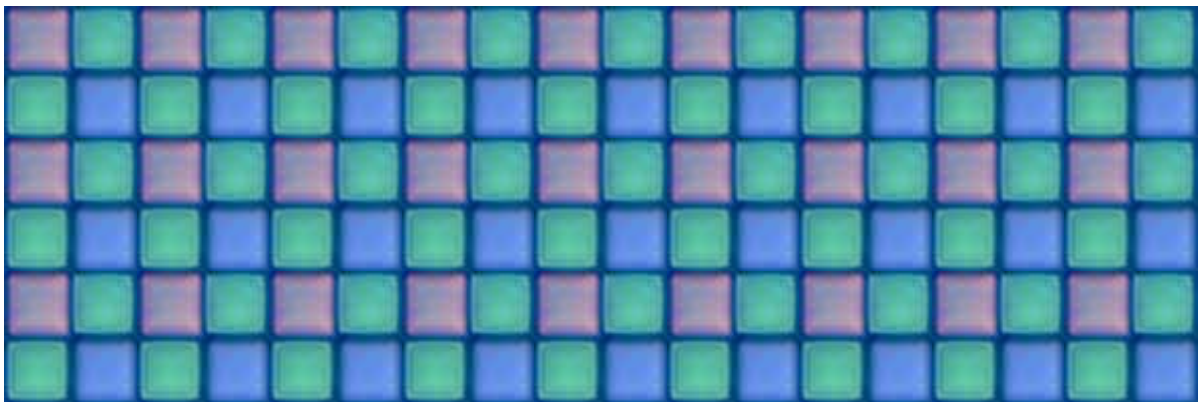
Image sensors record only the **gray scale**—a series tones ranging from pure white to pure black. Basically, they only capture a range of brightness.



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

How, then do sensors capture colors when all they can do is record grays? The trick is to use differently colored filters on the sensor's photosites to separate out the colors of the light reflected from a scene. On most sensors the filters are red, green, and blue (RGB), but some high end cameras use cyan, magenta, and yellow (CMYK) filters. There are a number of ways these filters are used, including the following:

- Three separate image sensors can be used, each with its own filter. This way each image sensor captures the image in one of the three colors.
- Three separate exposures can be made, changing the filter for each one.
- Filters can be placed over individual photosites so each can capture only one of the three colors. In this way, one-fourth of the photo is captured in red light, one-fourth in blue, and one-half in green. (Green is given more emphasis because of its importance.)



Each pixel on the usual 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. Courtesy of IBM.

Image Sensors and Colors

When photography was first invented, it could only record black & 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 author to comment "so you have to know how to paint after all!").



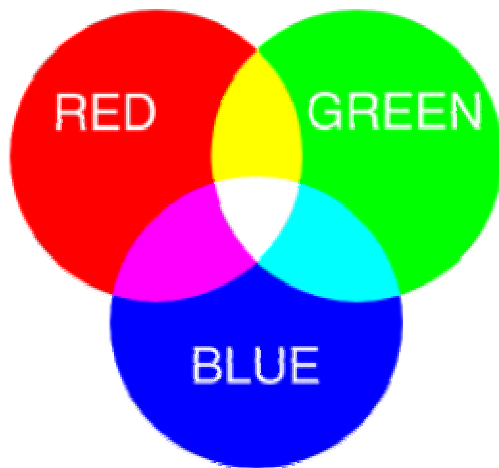
Smiling faces to greet you : mirroring contentment from within. (Title taken from label with hand-colored print.) An unidentified group of six people, two of whom are children (2 families?), standing in front of a possibly newly constructed sod house with a pitched sod roof, stovepipe, two windows and a door showing. With the people is a dog. One of the women is wearing a flat straw hat with a large ribbon. Likely taken in North Dakota.



"Fred Hultstrand copy of a photo printed from a glass plate. Glass plate borrowed from Howard O. Berg, Devils Lake, N.Dak. Brought in by Morris D. Johnson, Bismarck, N.Dak."--Back of hand-colored print. Photo likely taken by Job V. Harrison of Rock Lake, N.D. Courtesy of the [Library of Congress](#).

One major breakthrough was [James Clerk Maxwell's](#) 1860 discovery that color photographs could be formed using red, green, and blue 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 images were developed and then projected onto a screen with three different projectors, each equipped with the same color filter used to take its image. When brought into register, the three images formed a full color image. 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 in equal quantities, they form white. This system is used whenever light is projected to form colors as it is on the display monitor (or in your eye). The first commercially successful use of this system to capture color images was invented by the Lumerie brothers in 1903 and became known as the [Autochrome process](#). They dyed grains of starch red, green, and blue and used them to create color images on glass plates. (As you'll see in the section on printers, a few high-end cameras and all printers use the CMYK system. This system, called **subtractive colors**, uses the three primary colors cyan, magenta, and yellow (hence the CMY in the name—the K stands for an extra black). When combined in equal quantities, these colors form black.

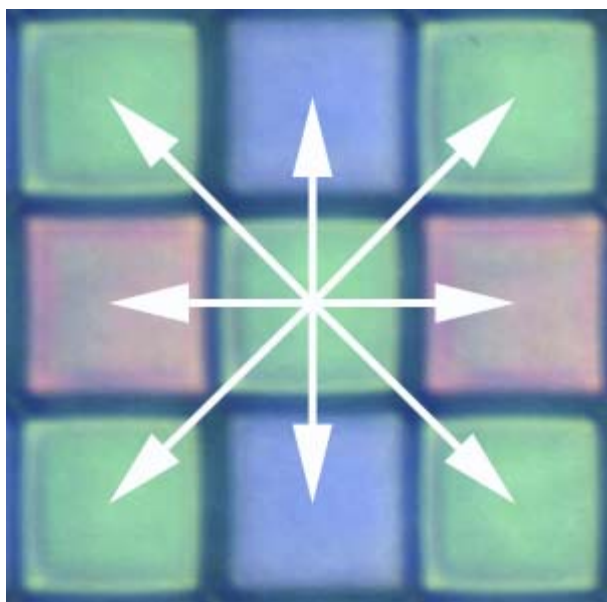


RGB uses additive colors. When all three are mixed in equal amounts they form white. When red and green overlap they form yellow, and so on.

Konica has an interactive Shockwave applet that allows you to drag cyan, magenta, and yellow versions of a photo and see how the colors combine to form a full-color image. Be sure to check it out.

From Black and White to Color

When three separate exposures are made through different filters, or three separate sensors are used, the three images captured in red, green, and blue are combined to form the full-color image. However, when red, green, and blue filters are placed directly over individual photosites on the sensor, some photosites capture the scene in one color, and others capture it in others. To generate the final full-color image, a process called **interpolation** is used. Interpolation uses the colors of neighboring pixels to calculate the two colors a photosite didn't record. By combining these two interpolated colors with the color measured by the site directly, the original color of every pixel is calculated. ("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.



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

Color Channels

Each of the three colors in an image can be controlled independently and is called a **color channel**. If a channel of 8-bit color is used for each color in a pixel—red, green, and blue—the three channels are combined to give 24-bit color.



When an image is open in Photoshop a dialog box shows the red, green, and blue channels so you can select the one you want to work on. The top image in the dialog box is the combined 24-bit RGB.

1.4 CCD AND CMOS IMAGE SENSORS

Until recently, CCDs were the only image sensors used in digital cameras. Over the years they have been well developed through their use in astronomical telescopes, scanners, and video camcorders. However, there is a new challenger on the horizon, the CMOS image sensor that may eventually play a significant role in some parts of the market. Let's compare these two devices.

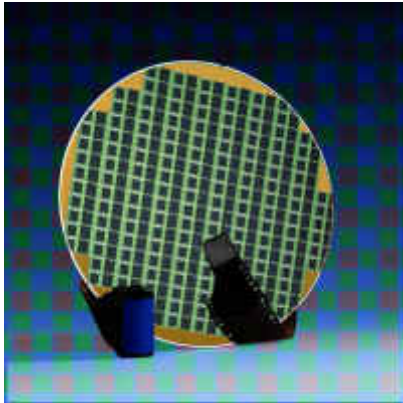
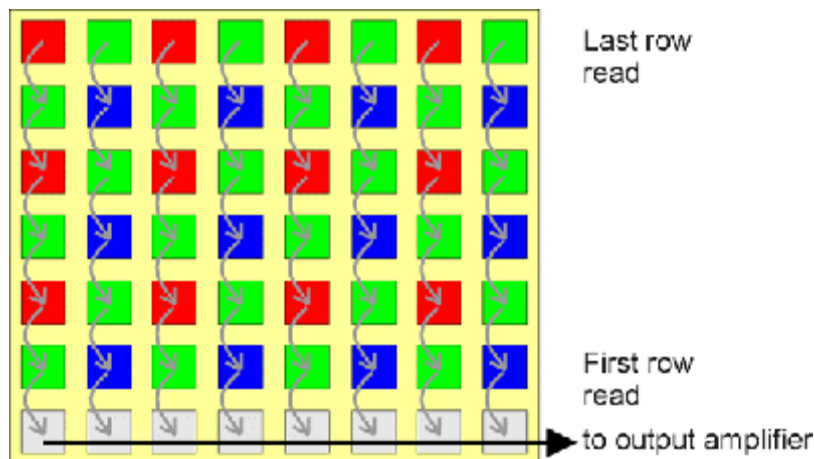


Image sensors are formed on silicon wafers and then cut apart. Courtesy of [IBM](#).

CCD Image Sensors

Charge-coupled devices (CCDs) capture light on the small photosites on their surface and get their name from the way that charge is read after an exposure. To begin, the charges on the first row are transferred to a **read out register**. From there, the signals are then fed to an amplifier and then on to an **analog-to-digital converter**. Once a row has been read, its charges on the read-out register row are deleted. The next row then enters the read-out register, 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.

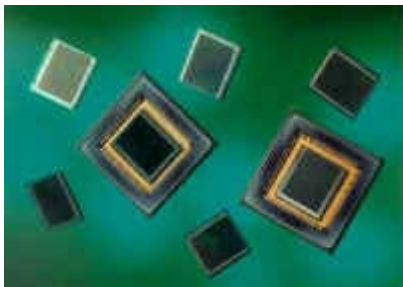
History The CCD was actually born for the wrong reason. In the 1960s there were computers but the inexpensive mass-produced memory they needed to operate (and which we take for granted) did not yet

exist. Instead, there were lots of strange and unusual ways being explored to store data while it was being manipulated. One form actually used the phosphor coating on the screen of a display monitor and wrote data to the screen with one beam of light and read it back with another. However, at the time the most commonly used technology was bubble memory. At Bell Labs (where bubble memory had been invented), they then came up with the CCD as a way to store data in 1969. Two Bell Labs scientists, Willard Boyle and George Smith, "started batting ideas around," in Smith's words, "and invented charge-coupled devices in an hour. Yes, it was unusual—like a light bulb going on." Since then, that "light bulb" has reached far and wide. Here are some highlights:

- In 1974, the first imaging CCD was produced by Fairchild Electronics with a format of 100x100 pixels.
- In 1975, the first CCD TV cameras were ready for use in commercial broadcasts.
- In 1975, the first CCD flatbed scanner was introduced by Kurzweil Computer Products using the first CCD integrated chip, a 500 sensor linear array from Fairchild.
- In 1979, an RCA 320x512 Liquid Nitrogen cooled CCD system saw first light on a 1-meter telescope at Kitt Peak National Observatory. Early observations with this CCD quickly showed its superiority over photographic plates.
- In 1982, the first solid state camera was introduced for video-laparoscopy.

CMOS Image Sensors

Image sensors are manufactured in wafer foundries or fabs. Here the tiny circuits and devices are etched onto silicon chips. The biggest problem with CCDs is that there isn't enough economy of scale. They are created in foundries using specialized and expensive processes that can only be used to make CCDs. Meanwhile, more and larger foundries across the street are using a different process called **Complementary Metal Oxide Semiconductor** (CMOS) to make millions of chips for computer processors and memory. This is by far the most common and highest yielding process in the world. The latest CMOS processors, such as the Pentium III, contain almost 10 million active elements. Using this same process and the same equipment to manufacture **CMOS image sensors** cuts costs dramatically because the fixed costs of the plant are spread over a much larger number of devices. (**CMOS** refers to how a sensor is manufactured, and not to a specific sensor technology.) As a result of this economy of scale, the cost of fabricating a CMOS wafer is lower than the cost of fabricating a similar wafer using the more specialized CCD process.



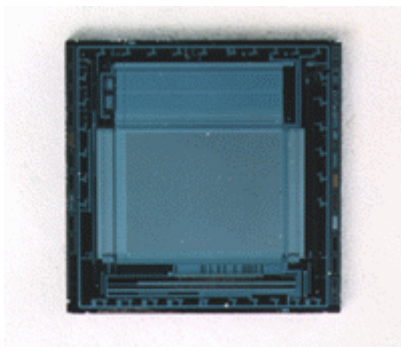
VISION's 800 x 1000 color sensor provides high resolution at lower cost than comparable CCDs. Image courtesy of [VISION](#).

Passive- and Active-pixel sensors (may drop)

There are two basic kinds of CMOS image sensors—passive and active.

- **Passive-pixel sensors (PPS)** were the first image-sensor devices used in the 1960s. In passive-pixel CMOS sensors, a photosite converts photons into an electrical charge. This charge is then carried off the sensor and amplified. These sensors are small—just large enough for the photosites and their connections. The problem with these sensors is noise that appears as a background pattern in the image. To cancel out this noise, sensors often use additional processing steps.
- **Active-pixel sensors (APSs)** reduce the noise associated with passive-pixel sensors. Circuitry at each pixel determines what its noise level is and cancels it out. It is this active circuitry that gives the active-pixel device its name. The performance of this technology is comparable to many charge-coupled devices (CCDs) and also allows for a larger image array and higher resolution.

Inexpensive CMOS chips are being used in low-end digital cameras. There is a consensus that while these devices may dominate the low-end of the camera market, more expensive active-pixel sensors will become dominant in niches.

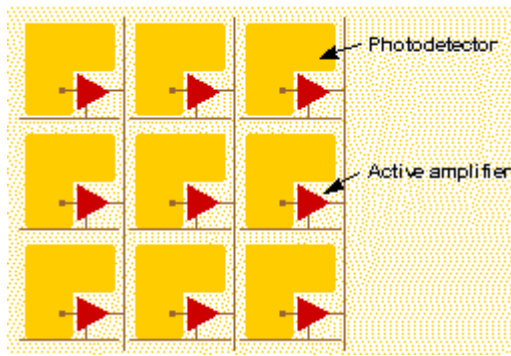


Toshiba Corporation fabricates a 1,300,000 pixel complementary metal oxide semiconductor (CMOS) image sensor. Courtesy of [Toshiba](#).

CMOS image sensor facts (may drop)

Here are some things you might like to know about CMOS image sensors:

- CMOS image sensors can incorporate other circuits on the same chip, eliminating the many separate chips required for a CCD. This also allows additional on-chip features to be added at little extra cost. These features include anti-jitter (image stabilization) and image compression. Not only does this make the camera smaller, lighter, and cheaper; it also requires less power so batteries last longer. It is technically feasible but not economic to use the CCD manufacturing process to integrate other camera functions, such as the clock drivers, timing logic, and signal processing on the same chip as the photosites. These are normally put on separate chips so CCD cameras contain several chips, often as many as 8, and not fewer than 3.
- CMOS image sensors can switch modes on the fly between still photography and video. However, video generates huge files so initially these cameras will have to be tethered to the mothership (the PC) when used in this mode for all but a few seconds of video. However, this mode works well for video conferencing although the cameras can't capture the 20 frames a second needed for full-motion video.
- While CMOS sensors excel in the capture of outdoor pictures on sunny days, they suffer in low light conditions. Their sensitivity to light is decreased because part of each photosite is covered with circuitry that filters out noise and performs other functions. The percentage of a pixel devoted to collecting light is called the pixel's **fill factor**. CCDs have a 100% fill factor but CMOS cameras have much less. The lower the fill factor, the less sensitive the sensor is and the longer exposure times must be. Too low a fill factor makes indoor photography without a flash virtually impossible. To compensate for lower fill-factors, micro-lenses can be added to each pixel to gather light from the insensitive portions of the pixel and "focus" it down to the photosite. In addition, the circuitry can be reduced so it doesn't cover as large an area.



Fill factor refers to the percentage of a photosite that is sensitive to light. If circuits cover 25% of each photosite, the sensor is said to have a fill factor of 75%. The higher the fill factor, the more sensitive the sensor. Courtesy of [Photobit](#).

- CMOS sensors have a higher noise level than CCDs so the processing time between pictures is higher as these sensors use digital signal processing (DSP) to reduce or eliminate the noise. The DSP is one early camera (the Svmini), executes 600,000,000 instructions per picture.

1.5 AREA ARRAY AND LINEAR IMAGE SENSORS

Hand a group of camera designers a theory and a box of components and you'll see fireworks. They will explore every possible combination to see which works best. Since there is usually no perfect solution to a given problem, a number of alternatives arise; each with its own unique pros and cons. At the moment, designers have two types of components to play with: area array and linear sensors.

Area Array Sensors

Most cameras use **area-array sensors** with photosites arranged in a grid. This allows the sensor to cover the entire image area and capture an entire image all at once, just like a film camera.



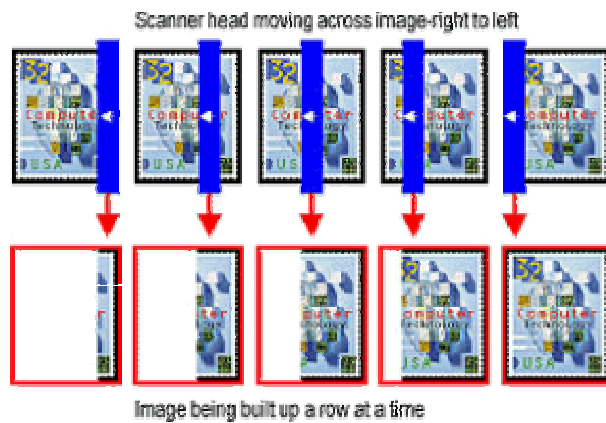
Area array image sensors have their photosites (pixels) arranged in a grid so they can instantly capture a full image. Courtesy of [VISION](#).

Area array sensors are incorporated into cameras in a variety of ways.

- **One-chip, one-shot cameras** use different color filters over each photosite to capture all three colors with a single exposure. This is the most common form of image sensor used in consumer-level digital cameras.
- **One chip, three shot cameras** take three separate exposures: one each for red, green, and blue. A different colored filter is placed in front of the image sensor for each of the colors. These cameras cannot photograph moving objects in color (although they can in black & white) and are usually used for studio photography.
- **Two-chip cameras** capture chrominance using one sensor (usually equipped with filters for red light and blue light) and luminance with a second sensor (usually the one capturing green light). Two-chip cameras require less interpolation to render true colors.
- **Three-chip cameras** use three full frame image sensors; each coated with a filter to make it red-, green- or blue-sensitive. A beam splitter inside the camera divides incoming images into three copies; one aimed at each of the sensors. This design delivers high-resolution images with excellent color rendering. However, three-chip cameras tend to be both costly and bulky.

Linear Sensors

Almost all scanners and a few high-end professional cameras, use image sensors with photosites arranged in one or more rows. To capture a picture, these **linear sensors** scan the image focused by the lens and build the image up a row at a time. The number of pixels captured in one direction is determined by the physical number of photosites on a row of the sensor. The number in the other direction is determined by how far the sensor is moved or "stepped" between rows. Cameras with these sensors are useful only for motionless subjects and studio photography. They are widely used for catalog photography and product shots..



As a linear sensor scans an image a line at a time it gradually builds up a full image.

Linear sensors are used in two ways:

- **Linear sensors** contain only a single row of photosites. To capture colors, a color filter is placed over the sensor for three separate exposures—one each to capture red, blue or green; or, cyan, yellow, and magenta.
- **Tri-linear sensors** use three rows of photosites—each with a red, green, or blue filter (or cyan, yellow, and magenta). Since each pixel has its own photosite, colors are captured very accurately in a single exposure.

1.6 IMAGE SIZES

The quality of any digital image, whether printed or displayed on a screen, depends in part on the number of pixels it contains. More and smaller pixels add detail and sharpen edges.



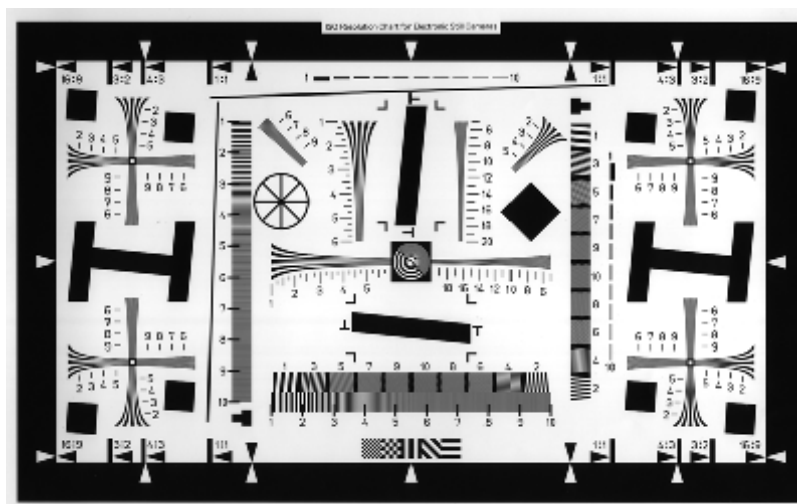
The number of pixels in an image determines its size and can have an affect on its resolution.

This table lists some standards of comparison. The numbers from various sources differ. One great thing about the Web is that you can talk back to an author and correct him.

Element	Pixel Count	Total Pixels
Color TV (NTSC)	320 x 525	168,000
Human eye	11,000 x 11,000	120 million
35-mm slide		The "Economist" magazine says it has 20 million or more. CMOS Imaging News says 5 to 10 million depending on the film. Another source says about 80 million pixels. Robert Caspe at SoundVision states that color negative film has 1000 pixels per inch while color positive film has 2000 pixels per inch.
1982 Kodak Disc camera film		3 million pixels—each about 0.0003 inch in diameter

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 larger screens. 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 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 device to resolve lines such as those found on a test chart.



PIMA / ISO Camera Resolution Chart. Courtesy of [Sine Patterns LLC](http://www.sinepatternsllc.com)

Pixel Count—Optical and Interpolated

When you read ads for imaging equipment, you sometimes have to read the fine print when it comes to "resolution." There are two kinds; optical and interpolated. The **optical resolution** of a camera or scanner is an absolute number because an image sensor's photosites are physical devices that can be counted. To improve resolution in certain limited respects, the number of pixels in an image can be increased using software. This process, called **interpolated resolution**, evaluates those pixels surrounding each new pixel to determine what its colors should be. For example, if all of the pixels around a newly inserted pixel are red, the new pixel will be made red. This same thing can be done in a photo editing program such as Photoshop by resizing the image. What's important to keep in mind is that interpolated resolution doesn't add any new information to the image—it just adds pixels and makes the file larger. In fact the one thing it doesn't have any effect on is resolution in its true sense—the ability to resolve closely spaced lines.

Size isn't everything!

The higher a camera's pixel count, the larger the image files that it creates. For this reason, some cameras allow you to specify more than one size when you take a picture. Although you are likely to get better results with a larger image, it isn't always needed—especially when the image is going to be displayed on the Web or printed very small. In these cases smaller images will suffice and because they have smaller file sizes, you'll be able to squeeze more into the camera's memory.

There is only one way to increase optical resolution, add more photosites to the sensor. Doing so isn't easy and creates other problems. For example:

- It requires that the sensor chip be larger and/or each photosite smaller. Larger chips with more photosites increase difficulties (and costs) of manufacturing. Smaller photosites must be more sensitive to capture the same amount of light.
- More photosites create larger image files, creating storage problems.

Pixels on the Screen

The resolution of a display monitor is almost always given as a pair of numbers that indicate the screen's width and height in pixels. For example, a monitor may be specified as being 640 x 480, 800 x 600, 1024 x 768, and so on.

- 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 640 x 480 display. That means there are 640 pixels on each row and there are 480 rows.

Images displayed on the monitor are very low-resolution. As you can see from the table below, the actual number of pixels per inch depends on both the resolution and the size of the monitor. Generally, images that are to be displayed on the screen are converted to 72 pixels per inch (ppi), a resolution held over from an early era in Apple's history. (The **red numbers** in the table are the pixels per inch for each combination of screen size and resolution.) As you can see from the table, this isn't an exact number for any resolution on any screen, but it tends to be a good compromise.

To understand the table, consider an example. You have two screens, each set to 800 x 600 resolution. One screen is 14" and one is 21". An 800 x 600 pixel image will fill either screen. However, on the larger monitor the 800 pixels on each row of the image are spread across a wider screen. It's for this reason that the pixels per inch decrease.

Resolution	Monitor Size				
	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

Pixels on the Page

Printer resolutions are usually specified by the number of **dots per inch** (dpi) that they print. (Generally **pixels per inch** refer to the image and display screen and **dots per inch** refer to the printer and printed image. Sometimes I think terminology shifts like this are done just to confuse us. In this book we use them interchangeably) For comparison purposes, monitors use an average of 72 ppi to display text and images, ink-jet printers range up to 1700 dpi or so, and commercial typesetting machines range between 1,000 and 2,400 dpi.

1.7 IMAGE COLOR

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**. Older PCs are stuck with displays that show only 16 or 256 colors. However, many newer systems include a video card and a monitor that 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 discern.



24-bit color makes it possible to display over 16 million colors.

TIP: Checking Your System

You may have to set your system to full-color, it doesn't happen automatically. To see if your Windows 95/98 system supports True Color, display Window's Start menu, click **Settings**, and then click **Control Panel**. Double-click the **Display icon** to open the Display properties dialog box. Click the **Settings** tab on the dialog box and check the **Color palette** setting.

The Arithmetic of Bits and Colors

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, display, or print 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

Some cameras and scanners will use 30 or more 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.



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) called true color.

Color depth is important at both ends of the spectrum. It's smart to match an image's color depth to the planned use. For example, if an image is to be printed, 24-bit color for colors to be bright and sharp. However, if an image is to be posted on the Web, most people are still using 256 color displays. Posting images with millions of colors will take them longer to download because the files are larger.

1.8 IMAGE FILE SIZES

When you take a photograph, the size of the image file is huge compared to many other types of computer files. For example, a low-resolution 640 x 480 image has 307,200 pixels. If each pixel uses 24 bits (3 bytes) for true color, a single image takes up about a megabyte of storage space. As the resolution increases, so does the file size. At a resolution of 1024 x 768, each 24-bit picture takes up 2.5 megabytes. Image file size is somewhat of an indicator of image quality. Very high end camera users often refer to file sizes instead of pixel counts. For example, someone may say a camera creates 30-Megabyte files. This is just a form of shorthand.

To make image files smaller and more manageable, almost every digital camera uses some form of compression. **Compressing images** not only let's you save more images on the camera's storage device, it also allows you to download and display them more quickly. In addition to compression, most cameras also allow you to control file sizes by choosing between two or three image sizes.

Compression

During compression, data that is duplicated or which has no value is eliminated or saved in a shorter form, greatly reducing a file's size. When the image is then edited or displayed, the compression process is reversed. There are two forms of compression—lossless and lossy—and digital photography uses both forms.

Lossless Compression

Lossless compression (also called *reversible compression*) uncompresses an image so its quality matches the original source. Although lossless compression sounds ideal, it doesn't provide much compression. Generally, compressed files are still a third the size of the original file, not small enough to make much difference in most situations. For this reason, lossless compression is used mainly where detail is extremely important as in x-rays and satellite imagery. A leading lossless compression scheme is LZW (Lempel-Ziv-Welch). This is used in GIF and TIFF files and achieves compression ratios of 50 to 90%

Lossy Compression

Although it's possible to compress images without losing some quality, it's not practical in many cases. Therefore, all popular digital cameras use a **lossy compression** (rhymes with *bossy*) that 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, the image degradation isn't obvious. However, enlarged prints show it off.

Although lossy compression does not uncompress images to the same quality as the original source, the image remains visually lossless and can appear normal. The trick is to remove data that isn't obvious to the viewer. 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 where the other identical pixels appear in the image. The leading lossy compression scheme is [JPEG](#) (Joint Photographic Experts Group) used in JFIF files (JPEG File Interchange Format). This scheme

allows you to select the degree of compression. Compression Ratios between 10:1 and 40:1 are common.

Because lossy compression affects the image, most cameras allow you to choose between different levels of compression. This allows you to choose between lower compression and higher image quality or greater compression and poorer quality. The only reason to choose higher compression is because it creates smaller file size so you can store more images, send them by e-mail, or post them on the Web. Most cameras give you two or three choices equivalent to Good, Better, Best.



Nikon 950 image resaved with lowest compression and highest quality.

Same image resaved with highest compression and lowest quality.

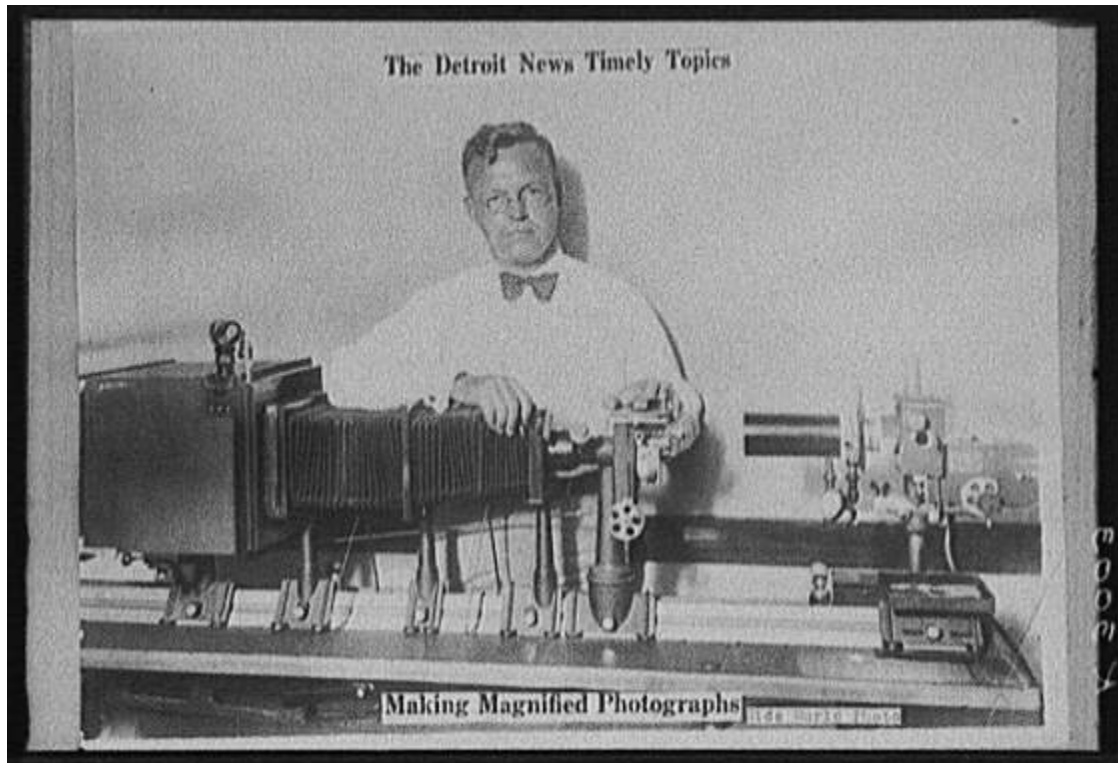
A few cameras allow you to select a mode that doesn't compress the image at all. This mode will give you the highest quality but stores the fewest images because the files are so large. Some cameras also offer a RAW mode that stores data off the image sensor without processing it. This keeps the file size smaller and speeds up the time between photos. The RAW file is processed into a full-color image only after its transferred to the computer.

Image Sizes

Instead of using compression, some cameras allow you to change resolution as a way of controlling file sizes. Because you can squeeze more 640 x 480 images into memory than you can 1800 x 1600 images, there may be times when you'll want to sacrifice quality for quantity.

1.9 IMAGE ARITHMATIC

When working with digital images, there are times when you need to convert among image dimensions expressed in inches, pixels, or pixels/dots per inch. Don't tune out here, it's only multiplication and division!



*It seems like you've always needed to know a little arithmetic to be a photographer.
Courtesy of the [Library of Congress](#).*

Converting dimensions in Pixels to Inches

As you've seen, images are described by their dimensions in pixels. However, printouts are described in inches or centimeters. What if you have a digital image and want to make a printout. To know how large an image will be when displayed or printed, you convert from pixels to inches (or cm). To do so, you divide the image's dimension in pixels by the resolution of the device in pixels per inch (ppi). For example, to calculate the dimensions of a 1500 x 1200 image being printed at 300 ppi you divide as follows:

$$\text{Width: } 1500 \text{ pixels} \div 300 \text{ ppi} = 5''$$

$$\text{Height: } 1200 \text{ pixels} \div 300 \text{ ppi} = 4''$$

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

$$\text{Width: } 1500 \text{ pixels} \div 600 \text{ ppi} = 2.5''$$

$$\text{Height: } 1200 \text{ pixels} \div 600 \text{ ppi} = 2''$$



A pixel in an image can be displayed as one pixel on the screen (look carefully for a tiny red dot).



The same pixel in the image can be displayed with 10 x 10 pixels on the screen.



Finally, the same pixel can be displayed with 100 x 100 pixels on the screen.

Converting Dimensions in Inches to Pixels

Scanning is the flip side of printing. You usually scan images measured in inches to create files expressed in pixels. To convert from inches to pixels you multiply the number of inches times the pixels per inch (ppi) of the device. For example, if you scan a 4" x 5" image at 300 ppi, you calculate the length of each side in pixels by multiplying its dimensions in inches by the number of pixels per inch as follows:

Width: 5" x 300 ppi = 1500 pixels

Height: 4" x 300 ppi = 1200 pixels



To convert from inches to pixels you multiply a length in inches times the pixels per inch. Here one side is 5 inches and the other is 4. To calculate the length of each side in pixels, you multiply those lengths by the number of dots per inch, in this case 300.

Converting Dimensions in Pixels to Pixels per Inch

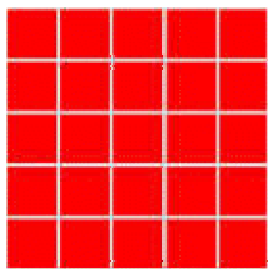
When you make printouts from images, pixels begin to show when the print is enlarged to a point where the pixels per inch (ppi) fall too low. If your printer can print a sharp image only at 300 or more pixels per inch, you need to determine if the size of the image you plan on printing will fall below this level. When you enlarge or reduce an image like this, the ppi change. To find out what the pixels (or dots) per inch becomes, you convert from the image's original size in pixels to its pixels per inch. For example, if you scan a slide at 2700 ppi, your scanned image is about 3712 pixels wide (a slide is about 1.375" wide). If you then print that scanned image so it's 10" wide, the pixels are stretched over a larger area so the ppi on the print falls from 2700 ppi to 371 ppi ($3712 \text{ pixels} \div 10 \text{ inches} = 371 \text{ pixels per inch}$). Also, if you know the size of the image in pixels, you can divide that number by the number of pixels you want to print per inch to determine the largest possible print size.



Here a slide is scanned at 2700 dpi. The resulting 3712 pixels are then spread across a 10-inch wide print. The dpi on the print are 371.

Resolution and Image Size

Surprisingly, the number of pixels in an image doesn't by itself indicate sharpness, or even size. The same number of pixels can occupy a small or large area on the screen or printout. As they are spread over a larger area, the perceived sharpness falls (from the same viewing distance). Conversely, if they are squeezed into a smaller area, perceived sharpness increases. The images on high-resolution screens or printouts look sharper only because the available pixels are grouped into a much smaller area—not because there are more pixels. The smaller an image is displayed from a given file, the sharper it will appear. When enlarged too much, sharpness begins to fade and eventually the square pixels will begin to show—the image becomes pixilated.



For sharpness to increase, pixel sizes must decrease.



The final size of an image depends on the resolution of the output device. Imagine laying two tile floors, one with large tiles and one with small. The one with small tiles will 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.



This graphic shows how a 640 x 480 image displays or prints on devices with different dots per inch. At 72 ppi it's 8.9" x 6.7", at 300 ppi it's 2.1" by 1.6", and at 1500 ppi, it's only 0.43" x 0.32".

You can see how this happens by studying the table below that lists a number of image resolutions found on Photo CD disks. An image with 768 x 512 pixels will just fit on the screen set to a resolution of 800 x 600. It will be displayed a little over 10 x 7 inches—about the size of a magazine page. That same image, printed on a 300 dpi printer shrinks to about 2.5 by 1.7 inches. On a 1500 dpi printer, the same image shrinks to a size smaller than a stamp.

Original		14" Screen @ 72 ppi		Printer 300 dpi		Printer 1500 dpi	
Width	Height	Width	Height	Width	Height	Width	Height
192	128	2.67	1.78	0.64	0.43	0.13	0.09
384	256	5.33	3.56	1.28	0.85	0.26	0.17
768	512	10.67	7.11	2.56	1.71	0.51	0.34
1536	1024	21.33	14.22	5.12	3.41	1.02	0.68
3072	2048	42.67	28.44	10.24	6.83	2.05	1.37
6144	4096	85.33	56.89	20.48	13.65	4.10	2.73

To make an image larger or smaller for a given output device, it must be resized in a photo-editing program or by the application you're printing it with. Resizing is done by interpolation. When made larger, extra pixels are added and the color of each new pixel is determined by the colors of its neighbors. When made smaller, some pixels are deleted.

CHAPTER 2, THE DIGITAL CAMERA



Introduction

With traditional cameras, the 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 memory device of some kind. These images stored in the camera, must then be transferred (downloaded) to a PC and stored on one of its storage devices—usually a hard drive. Often the images are compressed in the camera so there is room for more of them on the storage device.

2.1 THE DIGITAL CAMERA

Digital photography begins with you capturing images. You can do this with a film camera and then have the slides, negatives, or prints scanned. However, it's faster and easier to capture images with a digital camera that immediately gives you the images in digital form.

Although the technical process of digital photography is dramatically different from film-based photography, digital cameras are not that much different from film cameras. In most cases, digital camera manufacturers have attempted to retain many of the familiar features of traditional film cameras in their newer digital cameras. For example, lenses, shutters, and exposures are relatively unchanged. The biggest difference is the replacement of the film with a solid-state image sensor—usually a charge-coupled device (CCD).

Some digital cameras don't look at all like film cameras.



Types of Digital Cameras

Let's now look at the types, or families, of digital cameras currently available. As we do so, keep in mind is that no one yet knows what a digital camera should look like so you'll find all kinds of strange shapes. 35mm cameras have taken their familiar forms because they require room for the film and light path as well as prisms and such. Digital cameras are freed from many of these limitations so they can take new forms. During these early days, some manufacturers make their cameras look like familiar 35mm cameras, others veer off in new directions. Regardless of what they look like, the digital camera market is divided into two distinct segments; the consumer and professional markets. Let's take a look at these categories.



Digital camera are rapidly being integrated into other devices. For example, Handspring's™ handheld computers have a Springboard™ expansion slot. Soon you'll be able to plug in a Springboard digital camera module.

Consumer Cameras

The largest market for cameras is the consumer market. Within this category is a wide spectrum of cameras ranging from point and shoot type cameras all the way up to sophisticated cameras with professional-like creative controls.

Point and shoot cameras are generally small and inexpensive (at least in relative terms). They are fully automatic and usually don't provide a lot of overrides that give you creative control—that's why they are called "point and shoots." At the low end of this category are cameras with lower resolution whose images are limited to about 4 x 6 inches or so. Despite this small size, the images are ideal for Web pages and e-mail attachments.



The Nikon Coolpix 700 is a high-quality point and shoot camera with over 2-million pixels. Courtesy of [Nikon](#).

Positioned between the inexpensive point and shoot cameras and the very expensive professional cameras discussed next is a family of cameras based somewhat on the 35mm SLR model but designed exclusively for digital photography. These cameras, sometimes called **prosumer** cameras, currently have 2-megapixels or more. Generally, the higher resolution is combined with more advanced features such as through-the-lens (TTL) focusing, various exposure modes, and manual overrides of otherwise automatic controls such as focus and white balance. This is one of the fastest growing categories because these cameras appeal to serious amateur photographers and professionals who want creative control of their camera settings and prints up to about 8 x 10 in size.



The Nikon 950 is typical of the high-end consumer cameras. Courtesy of [Nikon](#).

Professional Cameras

Professional 35mm SLR or APS cameras have been adapted or used as models by replacing the film mechanism with an image sensor. These multi-megapixel cameras usually have more than 2-million pixels in their image sensors, with some having 6-million or so. The big advantage of these cameras is not just the quality of the images they take, but also the accessories that are available. Any lenses that work with the film-based camera also work with the digital version. Also, almost all of the features that are available in the film-based version are available on these digital models.



Nikon's D1 has a large 23.7 x 15.6mm 2.74-megapixel CCD for 2,012 x 1,324-pixel images. Courtesy of [Nikon](#).

Most advertising and many fine art photographs are taken with **large format cameras**. The large image size gives sharper images with brighter colors because it requires much less enlargement. In the digital camera arena, these medium and large format cameras are usually equipped with removable digital backs.



Large format hand-held cameras used to be very popular. Here's Jack Delano, a photographer for the Farm Security Administration/Office of War Information holding such a camera. Courtesy of the [Library of Congress](#).



BetterLight's digital back works with any 4x5 view camera, lenses, and accessories. It inserts into the camera just like a film holder. One model scans 16 bits per color at a resolution of 8000 x 10640 creating a 244 MB RGB image file. Courtesy of [BetterLight](#).

Because quality is of paramount importance in medium and large format photography, different technologies are often used. One way to improve quality is to use three image sensors instead of one, one for each of the colors red, green, and blue; or more likely, cyan, yellow, and magenta. Another approach is to use a single image sensor but make three passes for each image with a different color filter over the image sensor for each pass. Both approaches call for long exposure times and subjects that don't move—or even blink. The three separately captured image files can then be combined for a full color image or kept separate for printing purposes. In the minds of some people, this technology has reached the same standard as traditional film photography.

2.2 IN-CAMERA STORAGE MEDIA

When you take photographs, they have to be temporarily stored in the camera; usually on flash memory cards or spinning magnetic disks. Both types of storage devices share a number of features that include the following:

- They are erasable and reusable
- They are usually removable, so you can remove one and plug in another. This way, memory is limited only by the number of devices you have
- They can be removed from the camera and plugged into the computer to transfer the images. There are also printers with slots for these devices so you can make prints without a computer.

Because high quality digital image files are so large, it takes a lot of storage space to save them. For this reason, most cameras give you two options:

- You can remove one storage device, and replace it with another. This is like replacing a finished roll of film with a new fresh one.
- Most cameras allow you to choose between two or three modes of compression or image size. Using high compression or small images creates smaller image files so more fit onto a storage device. The tradeoff is that the images will not be as good as ones you might take at a lower compression or larger size.

The number of images you can store on any given device depends on a number of factors. These include the compression scheme used by the camera and the complexity of the scene. More complex scenes compress less than ones with fewer details. The number you can store is important because once you reach the limit you have no choice but to quit taking pictures or erase some of the ones you have already taken to make room for new ones. How much memory 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 camera better be able to store the same number of images or you'll be out of luck.

Let's take a look at some of the leading forms of storage in digital cameras, starting with the most common form—flash memory.

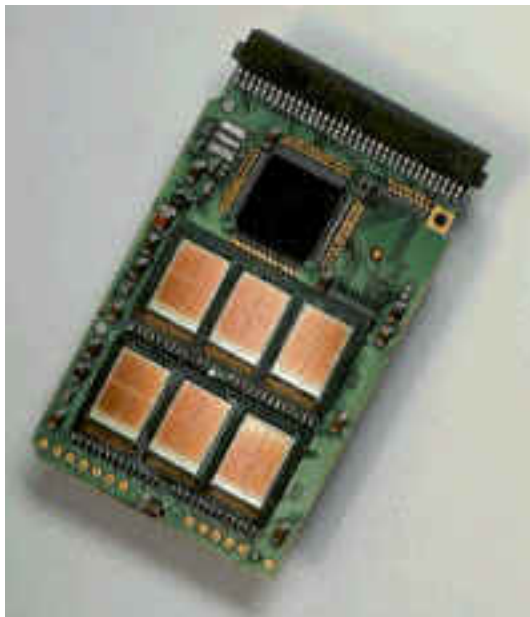
Flash Memory

As the popularity of handheld devices such as digital cameras, voice recorders, cellular phones, and computers has increased, so has the need for small, inexpensive memory devices. The type that's caught on is called **flash memory**.



Flash memory comes in a variety of shapes and sizes. Courtesy of [SanDisk](#)

Flash memory uses solid state chips to store your image files. In some ways, these chips are like the memory chips (RAM) inside your computer, but they have one important difference. They require no batteries and don't lose your data when the power is turned off. Your files are retained indefinitely without any power to the Flash components. These chips are packaged inside a case with connectors and the entire unit is called a **card**.



If you take the cover off a flash memory card, you find solid state circuits. Courtesy of [SanDisk](#).

Flash memory cards can be plugged into a camera, or into a card slot built into the computer or attached to it by a cable. These cards consume little power, take up little space, and are very rugged. They are also very convenient; you can carry lots of them with you and change them as needed (assuming you can afford lots of them).



Flash cards can be plugged into laptops, cameras, and desktop computers. Image courtesy of [SanDisk](#).

There is an old set up line for a joke that begins "I have good news and bad news." The good news is that we have these flash memory cards at all. The bad news is that they come in a variety of formats that are not interchangeable. As a result of the competition, cameras support a confusing variety of incompatible flash memory cards, each type supported by its own group of companies. Once you have a sizable investment in memory cards, you are locked into using only those cameras that support your format.

Types of Flash Memory

Until recently, most flash cards have been in the standard PC Card (PCMCIA) format that is widely used with notebook computers. However, with the growth of the digital camera and other markets, smaller formats have been introduced.

CompactFlash™ Cards

CompactFlash (CF) was developed by SanDisk Corp in 1994 and uses the popular ATA architecture that emulates a hard disk drive. These matchbook-sized cards come in two forms. The newer CF Type II cards (CF/2) are used for higher capacity flash cards and magnetic disk drives such as IBM's [Microdrive](#). These 5mm cards are thicker than the original 3.3mm CF Type I cards. Due to the different thicknesses, Type I cards will work in Type II slots, but not visa versa. To use CF/2 cards, your camera must have a CF/2 slot. This very popular storage media is supported by the [Compact Flash Association](#).



CompactFlash cards are one of the most popular storage media in digital photography. Image courtesy of [Lexar Media](#).

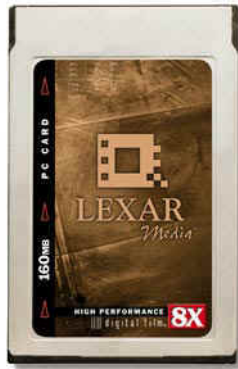


CompactFlash™ type II cards on the market. New thicker card will be standard in next generation of digital cameras because of the much higher storage capacities. Courtesy of [Delkin Devices](#).

SmartMedia

SmartMedia is the thinnest storage medium available, about one half the area of a credit card and shaped like a small floppy disk (45mm x 37mm x 0.76mm). Based on an ATA architecture, it's shaped so that it can only be inserted into the camera's memory slot the correct way. The major advantage of SmartMedia is its simplicity; it is nothing more than a flash chip on a card. It contains no controllers and no supporting circuitry, which reduces the size of the card as well as manufacturing costs. The problem with this approach is that the necessary controller functions must reside in the camera and therefore you may not be able to use newer cards in older cameras. A lot of the first cameras using this storage medium had to be returned to their ma

About the size of a thick credit card, PC Cards come in a variety of formats, but it's the Type I and Type II Cards that are used for flash memory. All PC cards have the same length and width (85.6 mm x 54.0 mm or 3.3" x 2.13"), but vary in thicknesses. Type I is 3.3 mm thick, Type II is 5.0 mm, and Type III is 10.5 mm. Slots for thicker cards can accept one or more of the thinner cards. For example, a Type IV slot holds one Type II card and one Type III, or two Type II cards.



Because PC Cards are larger than some other storage devices, they generally hold more data.. Courtesy of [Lexar Media](#).

Sony MemoryStick™

Sony Corporation has developed a new form of flash memory called a Memory Stick™, and shaped something like a stick of gum. Designed for use in a variety of devices, MemorySticks are also used in Sony digital cameras. The first versions have capacities of up to 32 Mbytes using currently available flash chips, but capacity will be increased as denser chips become available. One feature the MemoryStick has that other flash memory devices don't is an erasure prevention switch that eliminates the risk that you'll accidentally erase or write new photos over your existing images.



Sony's new Memory Stick™ cards are a new approach to flash memory storage. Courtesy of [Sony](#).



Rotating Magnetic Media

Instead of flash memory, some cameras are designed to use rotating magnetic media, much like the floppy and hard drives in your desktop system.

Floppy Disks

One of the oldest and cheapest storage mediums still in use is the 3½-inch floppy disk drive. You'd be hard pressed to find a system that can't read these disks. There is at least one digital camera that has chosen this medium as in-camera storage. Doing so increases the size of the

image files often compensate for this one shortcoming. Almost all other types of storage require special hardware or software on the computer before you can transfer files to it. It's the universal usability of floppy disks that makes them so attractive.



Sony's Digital Mavica has been a smashing success because of the convenience it brings you. The images are stored on floppy disks that can be read on almost any computer. Courtesy of [Sony](#).

High Capacity Floppy Drives

Over 5 billion 3.5-inch 1.44 MB computer diskettes have been sold since their introduction in 1984. During that same period, hard disk capacities of new PCs have increased from 20 MB to 20 GB or more. With such large drives, the old floppy's usefulness is very limited. There is a race on to replace the venerable floppy with newer **high capacity floppy disks**. There are three leading contenders in the race, the 100 megabyte [Iomega Zip disk](#), the 120 megabyte [SuperDisk](#), and the 200 megabyte [Sony HiFD](#). The three kinds of disks are not interchangeable so there will be confusion in the market for a while. Files stored on one disk can't be opened by the other drive. However, both SuperDisk and HiFD drives are backwards compatible and can read, write, and format traditional 1.44MB floppy disks.



Panasonic was the first to introduce a digital camera (the PV-SD4090) that saves images onto a high-capacity floppy disk; in this case the 120MB SuperDisk disk. To read the disks, you'll need a SuperDisk drive in your computer. Courtesy of [Addonics](#).

PC Cards

PC Cards in the Type III and Type IV versions are physically large enough to contain rotating hard disks that can hold an amazing number of digital images.



SanDisk's 300 Megabyte Type III card is a very small hard disk in a PC Card format. Image courtesy of [SanDisk](#).

Clik! disk drive

Iomega's Clik! drive uses a 40 megabyte 2-inch square disk. One battery operated version of the Clik! drive is designed to provide additional storage in the field. When the flash card in your camera is full, you can download the images to a Clik! mobile drive and return to shooting. Back at your home or office, just place the Clik! drive into its docking station and download the pictures to the computer. The 40 megabyte Clik! disks are a lot cheaper than flash memory so you can shoot for days without having to buy expensive flash memory cards.



[Iomega Clik! Disks](#) (left) and drive (below) let you download images in the field and keep on shooting. Courtesy of [Iomega](#).



A small 2-inch Clik! disk slides into the slot at one end and a flash card adapter, called the "Flash Memory Reader" fits in the other. This adapter has slots for both CompactFlash and SmartMedia cards. When you have all of the parts together, all you do is press a button and the image files are automatically transferred from the flash card to the Clik! disk. A small LCD display on the reader has icons for the drive and memory card and reader and a digital

gauge to let you know the percentage of the Clik! that is already full.

Hard Disks

One of the current drawbacks of compact flash memory cards is limited storage capacity. For high resolution cameras this is a real drawback. One solution is high speed, high capacity hard disk drives. Until recently, these drives were too big to be mounted inside cameras, but now that has changed. The dimensions of IBM's microdrive are the same as the CompactFlash Type 2 cards and can be used in any camera having a CompactFlash Type 2 slot.



IBM has introduced 340 MB and 170 MB microdrives for use in digital cameras. Courtesy of [IBM](#).

2.3 DOWNLOADING IMAGES

Once you have taken images, you have to transfer (download) them from the camera to your computer. As you download them, they are copied from the camera's storage device to a storage device on the computer. The procedures you use to download depend entirely on the software you are using. Usually, the camera's storage device looks to the computer just like another drive. You can then select and copy or move files that are displayed either as filenames or small thumbnail images.

What's Downloading?

When you transfer files between computers or other devices, you are uploading and downloading them. These terms simply refer to the direction of transfer. Uploading simply means you are sending the file to another system. Downloading means you are transferring a file from another computer to yours. In digital photography you download images from the camera to a computer and upload them back from the computer back to the camera.

Cable Connections

To connect a peripheral such as a camera, card reader, or printer to a computer, you usually run a cable from it to a socket on the computer called a **port**. There are a number of such ports ranging from the agonizingly slow serial port to the blazing fast Firewire. Let's take a look at each of them.

Serial Ports

Serial ports are mainly used to connect analog modems so you can connect to the Web. However, many digital cameras use the serial port to transfer image files to the computer. These ports carry only one bit of data at a time, so they have a real problem with speed—or, rather the lack of it. There isn't a slower port on the computer. Downloading an image through a serial port can take as long as 10 minutes.

Parallel Ports

Parallel ports, widely used for connecting printers to the computer, carry data 8 bits at a time on parallel paths so they are much faster than serial ports. For this reason, many flash card readers plug into the parallel port. If you use one, be sure it has a passthrough connector so you can plug the reader into the computer's only parallel port and then plug your printer into it. If the reader doesn't have this capability, you have to keep swapping cables.

SCSI Ports

Many devices such as scanners, hard drives, and CD-ROMS, can be connected to a SCSI port (Small Computer System Interface). One big advantage of this type of port is that more than one device can be connected to the same port. One device is plugged into the port and then another device is plugged into the first device. This process, called "daisy-chaining" reduces

the number of slots taken up by all of these devices. SCSI ports are fast but on PCs you need a SCSI card and the installing it can be difficult.

USB

As input and output demands have increased, serial, parallel, and even SCSI ports have become bottlenecks to system performance. To speed performance, USB (Universal serial Port) and even faster IEEE 1394 (Firewire) ports (described next), are being added to systems. Both of these ports have some features in common. They can each:

- Use thin cables to make connections easier.
- Daisy-chain devices so only a single port is needed on the computer.
- Support Plug and Play so the computer will automatically recognize a new device. (This is so flaky it's often referred to as "plug and pray.")
- Support hot plugging (adding and removing devices without first turning off the computer).
- Distribute power along its own cable so low-consumption devices can operate without a separate power cord.



USB replaces a variety of serial and parallel port connectors with one standardized plug and port combination. Courtesy of [Kavi](#).

Universal Serial Bus (USB) allows you to plug up to 127 devices into a USB port on the computer, or on any other device already plugged into that port. For example, you can plug a keyboard into the computer and then plug a mouse into the keyboard. USB is much faster than the older serial port and handles all but the most data hungry devices such as hard drives, fast CD-ROM drives, and high-end video equipment. USB works at 12 Mbps and the even newer USB2 will offer much higher transfer speeds.



Most computers come with one or two USB ports. However, you can connect hubs to those ports to add connections, much like you might plug a multi-socket extension cord into a wall socket so you can plug in all of your computer equipment.

FireWire

Firewire was originally conceived by Apple but has since been adopted by the entire computer and consumer electronics industry (in a kind of lackadaisical way). Sometimes referred to as IEEE 1394, Firewire is much faster than USB and is designed to connect up to

63 consumer electronics devices such as digital camcorders, digital cameras, and digital video disc players and also typical PC devices such as CD-ROM drives, printers, scanners, and hard drives. It also enables high-speed Internet connections. It can deliver a total transfer rate of 200 Megabits per second (Mbps)—or 25 Mbps for any one device.



Almost all new computer systems come with a USB port built-in. The faster and more expensive FireWire ports are less common. However, you can use an adapter card to add it to your system

Card Slots, Readers, and Adapters

To transfer images from the camera's storage media, you need a slot into which you can plug it. These slots are common on notebook computers, although you may need an adapter to use them, but on most desktop machines you need a card reader.

Card Slots

Most notebook computer come with PC Card slots. Sliding a PC Card into one of these slots makes it look to the computer just like a hard drive.



PC Card slots let you just slide in a card with your images on it. Nothing could be easier.

Not all flash cards fit all card slots and readers. However, there are adapters available that let you match cards and slots.



To use a small CompactFlash card in a larger Notebook computer's PC Card slot, you can get an adapter. Image courtesy of [SanDisk](http://www.sandisk.com).

Card Readers

Since most computers don't have PC Card slots, you need a standalone card reader that plugs into one of the computer's ports. You insert your flash card into the reader and download the images to your hard drive. Most of these card readers plug into the parallel port but faster USB models are becoming more common.



Lexar Media's The Digital Film Reader shares the parallel port with your printer. No additional hardware required. It reads both CompactFlash and SmartMedia cards. It transfers images at 500KB per second--20 times faster than a connection to a serial port. Image courtesy of [Lexar Media](#).

Wireless Connections

Cables can be a pain to hook up and use. There are two devices or technologies that let you avoid them entirely.

Floppy Disk Adapter

It seems the 3.5 floppy disk drive just won't go away. Not only does one camera store images on a floppy disk, now there is a [FlashPath](#) adapter you can slide into the drive's slot to read SmartMedia cards. Before or after it's in place, you slide a SmartMedia card into the FlashPath. This unique adapter doesn't require a cable connection. However, it does require driver software to operate and must be installed so it's not easily movable from one system to another.



FlashPath is shaped like a 3.5-inch floppy disk and slides into the standard drive slot found on almost all computers. Courtesy of [Toshiba](#).

Infrared

Infrared solves the hassle of connecting components with cables. Using a beam of infrared light a digital camera can "point-and-shoot" images to a device located nearby. The only small problem is that the light can't be obstructed and doesn't bend so you can't download through walls or around corners. Infrared devices currently follow the [Infrared Data Association](#) (IrDA) standard.



If your camera has infrared capability but your computer doesn't, you can buy an adapter that connects to one of the computer's ports. Courtesy of [ACTiSYS](#).

Cellular

Although you normally download images to a local computer, there are times when you'd want to download them to a remote one. To make this possible, Motorola and FlashPoint are working to make it possible to send and receive digital pictures over the Internet using Digita(tm)-enabled cameras and wireless Motorola iDEN (integrated digital wireless) phones. With an IP (Internet Protocol)-enabled plus series iDEN handset, such as the Motorola i1000plus(tm) connected to a Digita-enabled camera, photographers and in-the-field professionals, such as insurance adjusters, journalists, real estate agents and construction managers, will be able to capture, send and receive images wirelessly. The image transfer rate is 9.6 kbps.



Motorola's iDEN handsets are wireless phones that allow you to connect to the Internet so you can send and receive e-mail and share information and photos instantly with one or hundreds of individuals with the push of a button.

2.4 BATTERIES

Today's digital cameras aren't like the venerable old Leica that was fully mechanical. They are totally dependent on battery power to operate. You can easily run out of battery power after only a few pictures if you have the wrong batteries or don't conserve power. Also, batteries eventually wear out.



A battery charger and rechargeable batteries are necessities in digital photography. Courtesy of [Thomas-Distributing](#).

Types of Rechargeable Batteries

There are all kinds of batteries on the market. Here we'll discuss those types most often used in digital cameras.

Alkaline batteries are the kinds of batteries you usually find on drug store counters. They are OK in an emergency, but you'd go broke trying to use them in your camera on a regular basis.

NiCad (Nickel Cadmium) batteries are the most widely used type of rechargeable battery. They charge quickly, last approximately 700 charge and discharge cycles, and perform well in low temperatures. However, they do have one major problem. If you charge a NiCad battery, use only part of the charge, then recharge it again, it doesn't take a full charge. This is due to what's called "memory effects." The memory effect reduces the overall capacity and run time of the battery. (NiMH-Nickel Metal Hydride and LiOn-Lithium Ion don't have this problem.) Over time, the stored charge gets smaller and smaller and the battery fails more quickly when used. For instance, if you repeatedly recharge a 2 hour NiCad battery after using it for 30 minutes, it will develop a memory that limits the battery's run time to 30 minutes.

Memory effect is caused by gas bubbles accumulating on the battery's cell plates, reducing the area available to charge. To fix the battery and remove the gas bubbles, you need to condition it. Either fully discharge the batteries by leaving the camera and LCD on and then recharge them or use a battery charger/conditioner.



Most consumer digital cameras use AA size batteries.

NiMH (Nickel Metal Hydride) batteries are the most popular digital camera batteries. They run 30% longer on each charge than NiCad batteries of equal size. They are also more environmentally friendly because they are made from non-toxic metals. If they have any weakness, it's their overall life; lasting only about 400 charge and discharge cycles. These batteries do not suffer from memory effect.

LiOn (Lithium Ion) batteries last twice as long as NiMH batteries of equal size. They also don't lose their charge as quickly while in storage. However, being newer than other battery types, they are not available in as wide a range of models and they are more expensive. They have the same life expectancy as NiMH batteries, about 400 charge and discharge cycles. These batteries do not suffer from memory effect.

Battery Packs

An external battery pack containing NiMH batteries clips onto your belt and a cord connects it to the camera. One side benefit is that you can remove batteries from the camera and lighten it a lot. If you choose to leave them in the camera, they will act as a reserve when the battery pack starts running low on power.



Even the youngest photographer can benefit from a battery pack.

Solar Rechargers

You are sometimes off the road, perhaps on a canoe trip, and need to recharge your AA rechargeable batteries. To do so, you need a solar battery charger. These take a long time to charge batteries, but in some settings there may be no alternative.



Front



Back

Solar chargers can get the job done but they take a long time to do it. Courtesy of [Thomas-Distributing](#).

Battery Ratings

Batteries are rated by voltage and milliamp hours (mAH). Most NiMH batteries are either rated at 1300 mAH or 1500 mAH. Tests have shown that the 1300 mAH batteries will take between 125 and 145 shots while the 1500 mAH batteries capture between 140 and 165 shots. (Alkaline batteries capture 25 shots or less.)

Prolonging your Charge

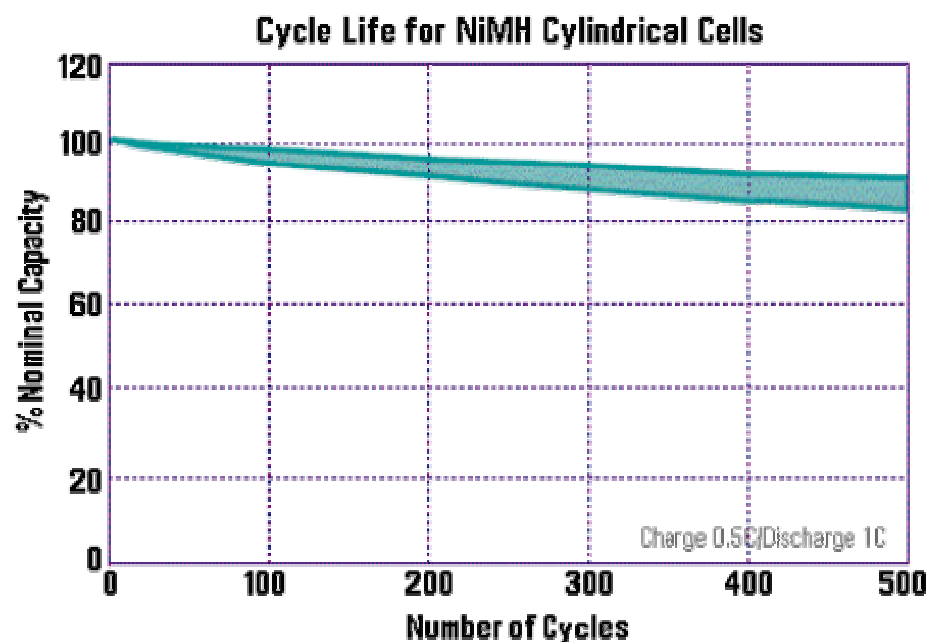
Digital cameras become nothing more than paper weights when their batteries run out. For

ways to prolong your battery's charge. Here are some of them.

- When you first get new batteries charge and recharge them a few times so they get fully charged.
- Turn off the power hungry LCD display and use the optical viewfinder. It's better for taking pictures anyway. When you have to use the LCD display, turn down its brightness, or use the black & white mode.
- Fully drain the battery charge and then re-charge them periodically. The easiest way to do this is with a conditioning charger that drains the battery before recharging it, or a pulse charger that uses a negative pulse to remove the gas bubbles.
- Occasionally clean the battery contacts in the camera and charger with a cotton swab and rubbing alcohol (isopropyl alcohol). Most charging problems are caused by dirty contacts on the battery or charger.
- When not using the camera for an extended period, remove the battery and store it in a cool, dry place. Also remove flash memory cards from the camera when not in use.
- An **AC adapter** allows you to plug the camera into the wall when the batteries run out or when you are using the camera to display, print, or download images.

Batteries Die Too

Batteries don't last forever. Depending on the type, they'll last between 400-700 recharge cycles. For heavy users that's about 1 to 2 years. Generally, you can tell when your batteries are failing when they no longer hold as long a charge or seem to be dying faster. (However, if they are NiCad-Nickel Cadmium batteries, you may just have to deal with the memory problem.)



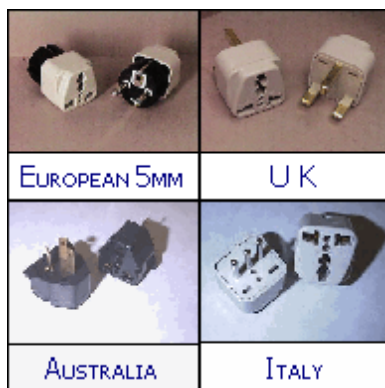
*NiMH batteries fade off gradually. Normally after 300 - 400 cycles, battery capacity will decrease 10 to 15%.
Courtesy of [Thomas-Distributing](#).*

Traveling

When flying, be sure your batteries are charged. You may be asked to turn your camera on at a security check point. Also, be sure you can recharge your batteries on the road. In the US, the power system is 110 volts and 60Hz. Overseas it's 220 volts and 50Hz. On top of this, there is an even wider variety of wall plugs. To plug in battery chargers, AC adapters, and notebook computers, you need an adapter kit: preferably a universal plug and voltage adapter.

- An adapter is used to plug a dual voltage appliance, converter, or transformer into a wall outlet that doesn't match the device.
- A converter is used with **electric** appliances such as hairdryers.
- A transformer is used with electronic devices such as computers.

Converters can harm appliances over time and shouldn't be used for more than a few hours at a time. Transformers can be used for longer periods. The only problem with transformers is that they are much heavier than converters.



One of the most complete suppliers you'll find is [Lashen Electronics](#).

Recycling

According to the EPA, each year over 2 billion used batteries are disposed into solid waste facilities in the United States. This constitutes 88% of the mercury and 54% of the cadmium deposited into our landfills. Many kinds of batteries, like those used in digital cameras, can be recycled instead of thrown away. When they wear out, try to take them back to the store where you bought them. Many stores collect the used batteries and then send them to a factory to be recycled. If not, contact local health officials to see if any provisions have been made for battery disposal.

2.5 OTHER CAMERA FEATURES

In addition to some of the features we have already discussed such as image size, storage, and download, digital cameras have lots of other features to be considered.



In the old days, a photographer had to cover his head with a black cloth so he could see the image (upside down) on the camera's ground glass. With digital cameras, you sometimes think you need to do the same to see the image on the LCD monitor. Courtesy of the [Library of Congress](#).

Frame Rate. Henri Cartier-Bresson is famous for his photographs that capture that "decisive moment" when random actions unfold into a single instant that makes an interesting photograph. His eye-hand coordination is unrivaled, and he was able to get the results he did because he was always ready. There was never any fumbling with controls and lost opportunities. Most digital cameras have an automatic exposure system that frees you from the worry about controls. However, these cameras have other problems that make decisive moments hard to capture.



Henri Cartier-Bresson in Brooklyn
Brooklyn, New York, New York, USA
1946

Photographer Henri Cartier-Bresson photographs the streets of Brooklyn outside a warehouse. His work in Brooklyn was chronicled in a photographic essay for Harper's Bazaar Magazine.

[www.corbis.com/Genevieve Naylor](http://www.corbis.com/GenevieveNaylor)
Image ID: RZ001315

There are two delays built into digital cameras that affect your ability to respond to fast action when taking pictures.

- The first is the delay you experience between pressing the shutter button and capturing the image. This delay, called the **refresh rate**, can be up to 1 or 2 seconds long. The delay is caused because when you press the shutter release, the camera first clears the image sensor, sets white balance to correct for color, sets the exposure, focuses the image, and even checks to see if the flash is charged.
- 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.

Both of these delays affect how quickly a series of photos can be taken, called the **frame rate**. If they take too long, you may miss a picture. Some cameras have a **burst mode** that lets you take one photo after another as long as you hold down the shutter button. To increase the frame rate, they often reduce the resolution used to capture the images. Some even divide the surface of the image sensor up into sections and store images in each section before processing them all at once. Another, and better way to reduce the recycle time is to temporarily store a series of images in the camera's RAM until they can be processed.

Creative controls. Almost all modern cameras offer a fully automatic mode so you can just point and shoot. However, you'll want to control the shutter speed to capture action, aperture to control depth of field, focus to control the sharpest plane, and exposure to control how light or dark the image is.

White balance. Not all whites are the same because they can be tinged with other colors. In film photography, color balance filters are placed over the lens to adjust colors and remove casts from various types of lighting. With digital cameras this is done by adjusting **white balance** so the camera correctly records white (although what it thinks is "right" might differ from what you think). It does so by adjusting the relative brightness of the red, green, and blue components so that the brightest object in the image appears white.

Exposure values (EV) indicate aperture and shutter combinations that give the equivalent exposures. For example, an EV of 3 represents an aperture of f/2.8 and a shutter speed of one second, or f/1.4 at 1/4 second. The EV range for a specific camera depends on its range of apertures and shutter speeds. A camera that has an EV range of 1 to 20, for example, has a

1 to 18. The EV range also indicates how a camera will work in both dim and bright light. For example, a camera that has a range starting at 0 or -1 is better in low light than one starting at 3. One with a range ending at 20 is better in bright light and at freezing fast action than one ending at 15. An EV range of 3-18 means the camera can use any of the aperture/shutter speed combinations shown in green.

Lenses. Currently all consumer digital cameras come with a single zoom lens. It's only expensive professional cameras that allow you to change lenses. Macro mode lets you take close-ups of things in nature, documents, or other small objects.

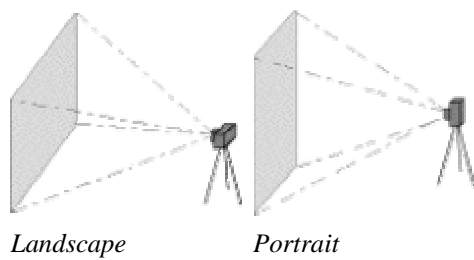
Size and Weight. The size and weight of a camera can have a pronounced effect on how much you like it. You're much less likely to take a bulky camera with you. If it fits in your shirt pocket, you'll probably take it with you everywhere. The problem is that adding features adds bulk and weight. There's no such thing as a perfect choice.

Built-in flash lets you take photos when available light is dim or non-existent. But it has serious limitations. These small flash units built into cameras don't have much range and aren't adjustable so you can't use bounce flash to soften shadows or position the flash away from the camera to eliminate red eye. Better digital cameras have an external **flash sync connector** so you can attach a more powerful flash to the camera and have it fire when you press the shutter button. Some cameras also have a **hot-shoe** into which you can mount a separate flash unit. Not only does this secure the flash to the camera, it also provides the electrical connections.

Image Preview. Many cameras have a preview screen that allows you to preview a picture before you take it and scroll through those you have already taken. If you need room for another image, you can find one you don't like as much and delete it.

Optical or Thru-the-lens Viewfinders. The image you see on a digital camera's preview screen is taken directly from the image sensor, so it is a true TTL (thru-the-lens) view. For some images, such as extreme close-ups, this screen is a great way to compose and focus the image. But for most images it isn't. For one thing, the image on the preview screen is hard to read in daylight. For another, you end up composing an image with the camera at arm's length, a difficult and tiring experience. (For best results, brace your elbows against your body to reduce camera shake.) To make framing images easier, better cameras provide an optical viewfinder. These are ideal for following fast action as it unfolds—waiting for the decisive moment. The better cameras include optical viewfinders that are coupled to the zoom lens and show the full area covered by the image sensor. The best offer thru the lens viewing just like a 35mm SLR camera.

Orientation Sensor. You can take photos in both landscape and portrait modes with any camera just by turning it 90 degrees. However, when you then view thumbnails, display the images on a connected TV, or load the images into the computer the portrait images are usually sideways and you have to rotate them (if possible). Some cameras sense then the camera is turned to portrait mode and automatically rotate those images for you. Portrait mode shows the image vertically. Landscape mode shows the image horizontally.



Continuous photography. Some cameras let you take a series of pictures. Any of the features can capture sequences that can be used to create animated GIFs for use on a Web page. To increase the frame rate, resolution is often reduced. A few cameras offer a better solution. They temporarily store images in RAM until they are processed. A few cameras allow **time lapse photography**—a series of pictures at specified intervals—perhaps to show a flower opening.

Self-timers allow you to get in the picture. You just start the timer and run like hell. Wireless remote controls allow you to retain your dignity. You just get in the picture area and then click a button. The problem is keeping the remote from being obvious in the image. A timer or remote control is also great in low-light situations. You can rest the camera on a table or tripod and use them to take the picture. This eliminates the camera shake that causes soft or blurred images.

Voice Annotation. Some cameras have built-in microphones that let you speak into your camera. This is a nice feature when you want to preserve comments about an image. These recordings are saved in sound files that can later be played back and edited on the computer.

Digital Print Order Form (DPOF) lets you specify the number of prints you want from each picture and store that information on a memory card along with the image file. Then, you take the card to a photography store or minilab, or use your own printer if it's designed to work with the system.

CHAPTER 3, THE CAMERA'S CREATIVE CONTROLS



Introduction

Serious digital cameras give you creative control over your images. They do so by allowing you to control the light and motion in photographs as well as what's sharp and what isn't. Although most consumer digital cameras are fully automatic, some allow you to make minor adjustments that affect your images. The best ones offer a wide range of controls-in some cases more than you'd find on a 35mm SLR. However, regardless of what controls your camera has, the same basic principles are at work "under the hood." Your automatic exposure and focusing systems are having a profound affect on your images. Even with your camera on fully automatic, you can indirectly control, or at least take advantage of the effects these controls have on your images.

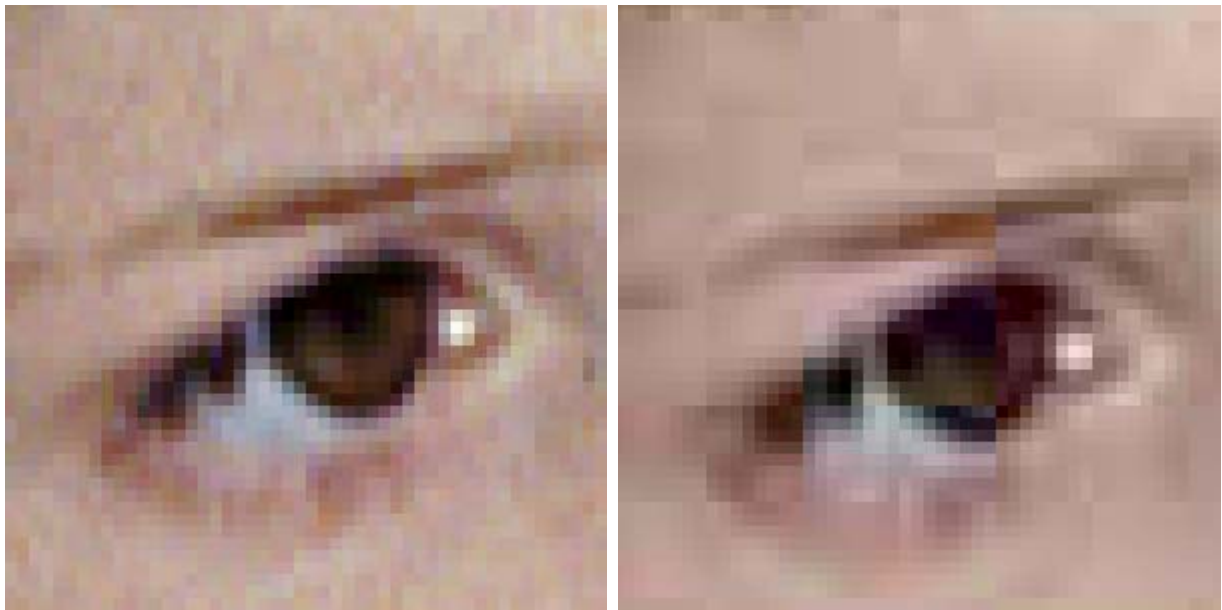
In this chapter, we'll first explore how you use the camera in various automatic modes and see what effect each of the settings has on your images. In the chapters that follow, we'll explore in greater depth how you take control of these settings, and others, to get the effects that you want.

3.1 CHOOSING IMAGE QUALITY AND SIZE

The size of an image file and the quality of the picture it contains depend in part on the number of pixels in the image and the amount of compression used to store it.

Compression

To make large image files smaller and more manageable, digital cameras store images in a format called JPEG after its developer, the Joint Photographic Experts Group and pronounced "jay-peg." This file format not only compresses images, it also allows you to specify how much they are compressed. This is a useful feature because there is a trade-off between compression and image quality. Less compression, sometimes called Fine mode, gives you better images so you can make larger prints, but you can't store as many images. More compression, in modes such as Normal or Basic, lets you store more images and makes the images better for making smaller prints, posting on a Web page, or sending as e-mail attachments. The only problem is that your prints won't be quite as good. For the highest resolution, some cameras offer an uncompressed format.



Here, two versions of the same image have been enlarged. The image on the left is uncompressed. The one on the right is a compressed JPEG file.

Image size

In addition to offering two compression modes, many cameras let you also change image size as a way of controlling the size of image files. Because you can squeeze more 640 x 480 (VGA) images into a storage device than you can squeeze 1600 x 1200 images, there may be times when you'll want to switch to a smaller size and sacrifice quality for quantity.

3.2 THE SHUTTER CONTROLS LIGHT AND MOTION

The shutter keeps light out of the camera except during an exposure, when it opens to let light strike the image sensor. The length of time the shutter is open affects both the exposure of the image and how motion is portrayed in it.

The Shutter and Exposure

Slower shutter speeds let more light strike the image sensor making an image lighter. Faster shutter speeds let less strike it and make the image darker.



In these pictures, the shutter was left open longer for the image on the right than for the one on the left. It's this longer exposure time that has made the image lighter.

The Way It Was: Early Shutter Designs

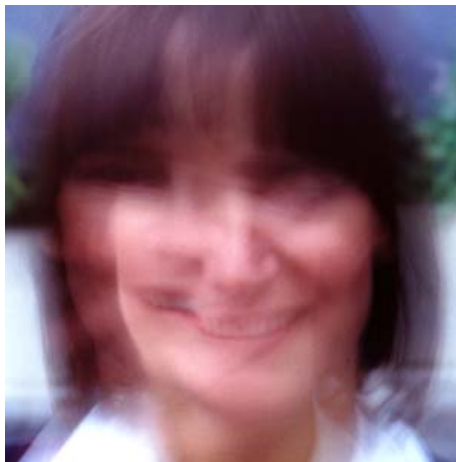
The shutter, used to control the amount of time that light exposes the image sensor, has changed considerably over the years. The earliest cameras, using materials that might take minutes to be properly exposed, came with a lens cap that the photographer removed to begin the exposure and then replaced to end it. As film became more sensitive to light and exposure times became shorter, faster shutters were needed. One kind used a swinging plate while another design used a guillotine-like blade. As the blade moved past the lens opening, a hole in the blade allowed light to reach the film.

The Shutter and Motion

In addition to controlling exposure (the amount of light that reaches the image sensor), the shutter speed is the most important control you have over how motion is captured in a photograph. Understanding shutter speeds is vital if you want to anticipate if a moving subject will appear in your image sharp or blurred. The longer the shutter is open, the more a moving subject will be blurred in the picture. Also, the longer it's open the more likely you are to cause blur by moving the camera slightly.



A fast shutter speed (left) opens and closes the shutter so quickly a moving subject doesn't move very far during the exposure, a slow speed (right) can allow moving objects to move sufficiently to blur their image on the image sensor.



Katie turned a little just as the shutter opened causing unwanted blur in the image.

Understanding Shutter Speed Settings

Although digital cameras can select any fraction of a second for an exposure, there are a series of settings that have traditionally been used when you set it yourself (which you can't do on many digital cameras). These shutter speed settings are arranged in a sequence so that each setting lets in half as much light as the next slowest setting and twice as much as the next fastest. The traditional shutter speeds (listed from the fastest to the slowest speeds) include 1/1000, 1/500, 1/250, 1/125, 1/60, 1/30, 1/15, 1/8, 1/4, 1/2, and 1 second. Although speeds faster than 1 second are fractions of a second most cameras display them without the numerator. For example, 1/2 second is displayed as 2.

3.3 THE APERTURE CONTROLS LIGHT AND DEPTH OF FIELD

The aperture diaphragm, a ring of overlapping leaves within the camera lens, adjusts the size of the opening in the lens through which light passes to the image sensor. As it changes size, it affects both the exposure of the image and the depth of field in which everything is sharp.

Aperture and Exposure

The aperture can be opened up to let in more light or closed (stopped down) to let in less. Like the shutter speed, the aperture is used to control exposure. The larger the aperture opening, the more light reaches the image sensor in a given period of time. The more light, the lighter the image.

The Way It Was: Early Apertures

A variety of designs in the past century and a half have enabled photographers to change the size of the lens opening. A form of the iris diaphragm, used in today's cameras, was used as early as the 1820s by Joseph Nicéphore Niépce, one of the inventors of photography. Waterhouse stops, used in the 1850s were a series of blackened metal plates with holes of different sizes cut in them. To change apertures the photographer chose the appropriate one and slid it into a slot in the lens barrel. With wheel stops, different size apertures were cut into a revolving plate. The photographer changed the size of the aperture by rotating the plate to align the desired opening with the lens.

Aperture and Depth-of-field

Like shutter speed, aperture also affects the sharpness of your picture, but in a different way. Changing the aperture changes the depth of field, the depth in a scene from foreground to background that will be sharp in a photograph. The smaller the aperture you use, the greater the area of a scene that will be sharp. For some pictures—for example, a landscape—you may want a smaller aperture for maximum depth of field so that everything from near foreground to distant background is sharp. But perhaps in a portrait you will want a larger aperture to decrease the depth of field so that your subject's face is sharp but the background is soft and out of focus.



A shallow depth of field can make part of an image stand out sharply against a softer background. This emphasizes the sharpest part of the image.



Great depth of field keeps everything sharp from the foreground to the background.

Understanding Aperture Settings

Aperture settings are called f-stops and indicate the size of the aperture opening inside the lens. Each f-stop lets in half as much light as the next larger opening and twice as much light as the next smaller opening. From the largest possible opening to increasingly smaller ones, the f-stops have traditionally been $f/1$, $f/1.4$, $f/2$, $f/2.8$, $f/4$, $f/5.6$, $f/8$, $f/11$, $f/16$, $f/22$, $f/32$, $f/45$. No lens has the full range of settings; for example, the standard lens on a digital camera will range from about $f/2$ to about $f/16$. Notice that as the f-stop number gets larger ($f/8$ to $f/11$, for example), the aperture size gets smaller. This may be easier to remember if you think of the f-number as a fraction: $1/11$ is less than $1/8$, just as the size of the $f/11$ lens opening is smaller than the size of the $f/8$ opening.

How wide you can open the aperture, referred to as its "speed," depends on the lens's maximum aperture (its widest opening). The term "fast lens" usually applies to lenses that can be opened to a wide maximum aperture for the focal length. For example, a lens with a maximum aperture of $f/2.6$ opens wider, and is faster, than a lens with a maximum aperture of $f/4$. Faster lenses are better when photographing in dim light or photographing fast moving subjects. With zoom lenses the maximum aperture changes as you zoom the lens. It will be larger when zoomed out to a wide angle, and smaller when zoomed in to enlarge a subject.

3.4 USING SHUTTER SPEED AND APERTURE TOGETHER

Both shutter speed and aperture affect the exposure, the total amount of light reaching the image sensor, and so control a picture's lightness or darkness. The shutter speed controls the length of time the image sensor is exposed to light and the aperture controls the brightness of that light. You, or the camera's autoexposure system, can pair a fast shutter speed (to let in light for a short time) with a wide aperture (to let in bright light) or a slow shutter speed (long time) with a small aperture (dim light). Speaking of exposure only, it doesn't make any difference which of the combinations is used. But in other ways, it does make a difference, and it is just this difference that gives you some creative opportunities. You're always balancing camera or subject movement against depth of field. This is because a change in one causes a change in the other. Let's see why.

Each setting is 1 "stop" from the next and lets in half or twice the light of the next setting. A shutter speed of 1/60 sec. lets in half the light that 1/30 sec. does, and twice the light of 1/125 sec. An aperture of f/8 lets in half the light that f/5.6 does, and twice the light of f/11. If you make the shutter speed 1 stop slower (letting in 1 stop more light), and an aperture 1 stop smaller (letting in 1 stop less light), the exposure doesn't change. However, you increase the depth of field slightly and also the possibility of blur.

For general shooting you need a medium shutter speed (1/60 sec. or faster) and a medium aperture (f/5.6 or smaller). Slower shutter speeds will show up on the image as overall blur unless you support the camera, perhaps with a tripod.

- For fast-moving subjects you need a fast shutter speed (although the focal length of the lens you are using, the closeness of the subject, and the direction it's moving also affect motion).
- For maximum depth of field, with the entire scene sharp from near to far, you need a small aperture (although the focal length of the lens and the distance to the subject also affects depth of field).



Photographing these fast-moving Blue Angels from the deck of a moving boat took a fast shutter speed to prevent blur caused by subject or camera movement. Great depth of field was also needed to keep the boats in the foreground and background sharp.

An Analogy

One way to think of shutter speeds and apertures is as faucets. You can fill (expose) a bucket with a small faucet opening (aperture) over a long time (shutter speed), or a large faucet opening in a shorter period. No matter which combination you choose, the bucket can be filled the same amount.

3.5 CHOOSING EXPOSURE MODES

Many cameras offer more than one exposure mode. In fully automatic mode the camera sets the shutter speed and aperture to produce the best possible exposure. However, there are two other automatic exposure modes that are widely used in photography—aperture-priority and shutter-priority. All modes give equally good results in the vast majority of photographic situations. However, when you photograph in specific kinds of situations, these alternate exposure modes may have certain advantages.

Let's take a look at each of the available modes.

- Fully Automatic, or program mode, sets the shutter speed and aperture, white balance, and focus without your intervention. This mode allows you to shoot without paying attention to settings so you can concentrate on composition and focus.
- Aperture priority (or aperture preferred) mode lets you select the aperture (lens opening) needed to obtain the depth of field you want and the exposure system automatically sets the shutter speed to give you a good exposure. You select this mode whenever depth of field is most important. To be sure everything is sharp, as in a landscape, select a small aperture. The same holds true for close-up photography where depth of field is a major concern. To throw the background out of focus so it's less distracting in a portrait, select a large aperture.
- Shutter priority (or shutter priority) mode lets you choose the shutter speed you need to freeze or deliberately blur camera or subject movement and the camera automatically sets the aperture to give you a good exposure. You select this mode when the portrayal of motion is most important. For example, when photographing action scenes, such as those encountered by wildlife photographers, sports photographers, and photojournalists, shutter-priority mode might be best. It lets you be sure your shutter speed is fast enough to freeze the action or slow enough to blur it
- Manual mode lets you select both the shutter speed and the aperture.

One of the things that makes photography so enjoyable is the chance you get to interpret a scene in your own way. Shutter speeds and aperture controls are two of the most important ways you have of making a picture uniquely your own. As you become more familiar with their effects on a picture, you will find yourself making choices about them more instinctively: knowing, for example, that you want only the main subject sharp and so turning to a larger aperture.



Shooting down from an upper level at the Guggenheim Museum froze the two people talking, but blurred everyone walking by.



Leaving the shutter open for an extended period of time, leaves light trails in the image created by the taillights of a passing car.



Photographing the U. S. Constitution from the deck of a moving speedboat with a long lens took a fast shutter speed.

CHAPTER 4, CONTROLLING SHARPNESS



Introduction

One of the first things you notice about a photograph is whether or not it is sharp. Extremely sharp photographs reveal a richness of detail, even more than you would normally notice in the original scene. If the entire image isn't sharp, your eye is immediately drawn to the part that is.

When learning to control sharpness, the first goal is to get pictures sharp when you want them sharp. If your photos aren't as sharp as you want them to be, you are probably experiencing one of the following effects:

- **Focus.** If nothing in your image is sharp or if your central subject is not sharp but other parts of the photograph are, your camera was improperly focused.
- **Depth of Field.** If your central subject is sharp but the background or foreground is less so, you probably didn't use a small enough aperture to get the depth of field you wanted.
- **Camera Movement.** If the image is blurred all over, with no part sharp, the camera moved during the exposure. Some dots appear as lines and edges blur as the image is "painted" onto the moving image sensor.
- **Subject Movement.** When some of the picture is sharp but a moving subject appears blurred, the cause is too slow a shutter speed.

4.1 ELIMINATING CAMERA MOVEMENT

Unwanted camera movement during the exposure is probably the major cause of unsharp photographs. You can reduce this problem in bright light and when using flash simply by holding the camera steady and depressing the shutter release smoothly. At slow shutter speeds, such as those you get in dim light, particularly with a lens zoomed in to enlarge a subject, you need a camera support.

As you zoom your lens in on a subject, you are increasing the lens's focal length. As you zoom back out, you're reducing it. The focal length, and the amount the image is magnified, determines the minimum shutter speed you need to use to hand-hold the camera and avoid blur. The rule of thumb is never to hand-hold the camera at a shutter speed lower than your lens' focal length.



Technology has improved but the need for a steady hand, or a tripod, has remained constant. Courtesy of the [Library of Congress](#).

Supporting a Camera

When the light is dim, and you aren't using flash, you need to support the camera or you'll get blur in your images. One way to do this is to lean against a wall or tree and brace yourself with your elbows tight to your body. You can also find a branch or railing to rest the camera on. For real stability you need a small tripod or an even easier to carry monopod.

Holding the camera correctly, bracing it, and breathing correctly can also reduce camera motion. Use the optical viewfinder to take photos because you can brace the camera against

your face instead of holding it out at shaky arms' length. Just before taking a shot, inhale deeply, then exhale and hold your breath while smoothly depressing the shutter-release button. When holding the camera for both horizontal and vertical photographs use your right finger to press the shutter-release button and your left hand to support the camera.



The camera was steady in the left picture and moved in the right one.

Using the Selftimer or Remote Control

Almost all digital cameras have a self-timer and a few have a remote control. Although often used to give you time to get into the picture, the self-timer is also a great way to reduce blur when photographing in dim light. Just place the camera on a secure surface, compose the image, and use the timer or remote to take the exposure.

Increasing Sensitivity

To reduce blur caused by camera movement, some cameras let you increase the image sensor's sensitivity (or ISO) to light although this adds some grain to the image. Increasing the sensitivity means less light is needed for a picture so the shutter speed is higher. Increasing sensitivity is a good way to get pictures without flash in places such as concerts and museums where flash is prohibited.

4.2 SHARPNESS ISN'T EVERYTHING

Your photos don't always have to be sharp to be effective. In many cases, it's better to have part of the scene sharper than the rest. Your pictures can be sharp or unsharp in different ways. The first way concerns motion. Several factors affect the way motion is captured in images. These include your image sensor's speed, the overall brightness of the scene, lens focal length, and subject speed, direction, and distance. Another kind of sharpness concerns depth of field, how much of the scene will be sharp in the image. Even if you are photographing a static scene, your picture may not be sharp if you do not have enough depth of field. However, a shallow depth of field can be used to make a busy background less distracting by having it out of focus in the picture. Several factors affect depth of field, including lens aperture, lens focal length, and subject distance.



Motion in a scene can be frozen or blurred depending on the shutter speed and other factors. Blur can be used creatively to evoke a feeling of motion as in this shot of a waterfall in Yosemite National Park.



Shallow depth of field can focus attention on a foreground subject by making the background less sharp.

4.3 HOW TO PHOTOGRAPH MOTION SHARPLY

The sharpness of different parts of an image helps direct the viewer who tends to look first at the most sharply focused part of the picture. In addition, sharpness itself can be part of the message of the photograph. The immobility of a frozen figure can be made more apparent by blurring people moving in the background.

Blur in an image is caused when all or part of a subject focused onto the image sensor moves when the shutter is open. To show a moving subject sharply, the shutter needs to open and close before the image on the sensor moves a significant amount. In other words, you need to use a fast shutter speed. But just how fast is fast enough? The answer depends on several factors. Because several variables are involved, you can't always predict how motion will be portrayed in the final photograph. So take more than one shot if possible. Try shooting from a different angle or perhaps wait for a pause in the action. You are much more likely to get a good shot if you have several to choose from.

Speed of Subject

The faster a subject is moving, the faster the shutter speed you need for a sharp image. However, it's not the speed of the subject in the real world that determines blur. It's how far the subject moves on the image sensor while the exposure is being made. This depends not just on the subject's actual speed, but also on the direction of its movement, its distance from the camera, and how far the lens is zoomed.

Direction of Movement

When the shutter is open, a subject moving parallel to the image sensor will cross more of the pixels on the sensor and be more blurred than a subject moving directly toward or away from the camera. This is why you can use a slower shutter speed to sharply photograph a child who is running toward, or away from you, and not the same child running from one side of the scene to the other.



The shutter speed froze the central dancer but was slow enough to blur the others. This makes the central dancer the most important person in the photograph.

Distance to Subject and Focal Length of Lens

If a subject is close to the camera, even slight movement is enough to cause blur. A subject—or part of one—far from the camera can move a considerable distance before its image on the image sensor moves very much. The focal length of the lens can also affect the apparent distance to the subject. Increasing the focal length of your lens—for example, zooming in on a subject—has the same effect as moving closer to your subject. The more you are zoomed in on it, the less a subject has to move in order to have its image move on the image sensor and become blurred.

To visualize the effects of distance on blur, look out the side window of a speeding car (but not when you're driving). The objects in the foreground seem to fly by while those on the horizon don't seem to move at all.



On this speeding train, the part closest to the camera looks the most blurred while the farthest part looks sharper. Since all parts of the train are moving at the same speed, this shows how distance affects blur.

How To: Increasing Sharpness of Moving Objects

- Photograph fast moving subjects heading toward or away from you.
- Move farther back from the subject.
- Zoom the lens to a wider angle of view.
- Switch to shutter priority mode and select a fast shutter speed such as 1/500. (See Topic 0.0.)
- Increase the sensor's sensitivity to light although this adds some grain to the image. (See Topic 0.0.)

4.4 FOCUS AND DEPTH OF FIELD

If you look around you—the book in your hand, the chair across the room, the far wall—everything seems to be sharp. That is because your eyes refocus every time you look at an object at a different distance. But the sharpness you see when you glance at a scene is not always what you get in a photograph of that scene. To understand why not, you have to understand focus and depth of field.

Focus

Focus is only one of the factors affecting the apparent sharpness of your photographs, but it is a critical one because it determines which parts of the picture will be sharpest—called the plane of critical focus. You will have much more control over the final image if you understand how focus relates to the overall sharpness of a scene.



Imagine the part of the scene on which you focus as a flat plane (much like a pane of glass) superimposed from one side to the other of a scene, so that the plane is parallel to the back of the camera or the image sensor. Objects falling exactly on this imaginary plane will be in critical focus, the sharpest part of your picture. This plane of critical focus is a very shallow band and includes only those parts of the scene located at identical distances from the camera. As you point an autofocus camera at objects nearer or farther away in the scene, the plane of critical focus moves closer to or farther from the camera. As the plane moves, various objects at different distances from the camera come into or go out of critical focus.

Depth of Field

A lens can only bring objects at a single distance from the camera into critically sharp focus. But if you look at photographs, you can see a considerable area of the scene from near to far that appears sharp. Even though theoretically only one narrow plane is critically sharp, other parts of the scene in front of and behind the most sharply focused plane appear acceptably sharp. This area in which everything looks sharp is called depth of field. Objects within the depth of field become less and less sharp the farther they are from the plane of critical focus. Eventually they become so out of focus that they no longer appear sharp at all.

Often it doesn't matter so much exactly what you are focused on. What does matter is whether

or not all of the objects you want to be sharp are within the depth of field so they appear sharp. If you want a large part of the scene to be sharp, you can increase the depth of field. You can decrease it if you want less of the scene sharp. In some scenes, you can significantly increase or decrease the depth of field simply by shifting the point on which you are focused or by changing the aperture setting.

The near and far limits of depth of field are shown here as two planes (B and C), parallel to the plane of critical focus (A). Actually, they are usually not visible as exactly defined boundaries. Nor can you usually find the plane of critical focus by looking at a picture. Instead, sharp areas imperceptibly merge into unsharp ones. Notice that in the diagram the depth of field is not evenly divided. At normal shooting distances, about one-third of the depth of field is in front of the plane of critical focus (toward the camera), and two-thirds is behind it (away from the camera). When the camera is focused very close to an object, the depth of field becomes more evenly divided.

Plane of Critical Focus

The plane of critical focus in your image will be the area that falls within the focus area in the center of the viewfinder when you press the shutter-release button halfway down.

Tip

To control depth of field, switch to aperture preferred mode and select a small aperture for great depth of field or a large aperture for shallow depth of field. (See page 15.)

Focus Settings

Most digital cameras have an autofocus system that automatically adjusts the focus to make the subject in the center of the viewfinder appear critically sharp. However, some cameras provide other ways to focus and this is a good thing. Autofocus often has trouble focusing in scenes with little contrast, when the object in the focus point is brighter than the rest of the scene, when the subject is poorly illuminated, when both near and distant objects fall within the focus point, or when the subject is moving quickly. If the camera can't focus, some cameras beep or blink a lamp. If this happens, use focus lock to focus on a subject at the same distance. Some cameras also let you switch to manual focus.

Using focus lock

To change the position of the plane of critical focus, you can use a procedure called focus lock. Most digital cameras have a two-stage shutter-release button. When you press it down halfway, it sets focus, exposure and white balance. Some cameras beep and illuminate a lamp when these readings are locked in. If you don't release the shutter-release button you can then point the camera anywhere else in the scene and the settings remain unchanged. This lets you set the focus at any distance from the camera to control both focus and depth of field.

How To: Using Focus Lock

1. In record mode, point the camera so the item you want to lock on is in the focus area in the center of the viewfinder.

2. Press the shutter-release button down halfway and hold it there to lock in the focus.
3. Without releasing the shutter-release button, recompose the scene and press the shutter-release button the rest of the way to take the picture.



A small aperture gave enough depth of field to keep both foreground and background figures sharp.

4.5 CONTROLLING DEPTH OF FIELD

Sharpness—or the lack of it—is immediately noticeable when you look at a photograph. If you are making a portrait, you want only the person to be sharply focused, but not a distracting background. In a landscape, on the other hand, often you will want everything sharp from close-up rock to far away mountain. Once you understand how to control depth of field, you will feel much more confident when you want to make sure something is—or isn't—sharp.

To control how deep or shallow depth of field is, you have three factors to work with.

- **Aperture size.** The smaller the size of the lens aperture (the larger the f-number), the greater the depth of field. The larger the aperture, the shallower the depth of field.
- **Camera-to-subject distance.** As you move farther from the subject you are focused on, you increase depth of field. As you move closer, you decrease it.
- **Lens focal length.** Zooming out to a wider angle of view increases depth of field. Zooming in decreases it.

Each of these three factors affects depth of field by itself, but even more so in combination. You can get the shallowest depth of field with a lens zoomed in on a nearby subject using a large aperture. You get the deepest depth of field when you are far from a subject, with the lens zoomed to a wide angle, and using a small aperture.



Here the greatest possible depth of field was used to keep everything sharp from the fighter's needle nose to the background.



Here the camera's depth of field was just deep enough to keep the legs in focus. Parts of the image closer to the camera and further away become increasingly less sharp.

4.6 CAPTURING MAXIMUM DEPTH OF FIELD

Many times when you are photographing you will want to get as much depth of field as possible because important parts of a scene are both near to and far from the camera, and you'll want all of them to be sharp. Maximum depth of field seems particularly important for photographs of landscapes and other scenes where a distant horizon is a part of the picture.

When a subject extends to the far distance, many photographers unthinkingly focus on that part of the scene—or on infinity. Infinity in photographic terms, is an inclusive term that designates everything from about 40 ft. to as far as you—or the lens—can see. So when you are focused on infinity everything from that point and beyond will be sharp. But since one-third of the available depth of field falls in front of the point on which you are focused and two-thirds behind it, focusing on infinity wastes two-thirds of your depth of field because everything from the infinity point and beyond is going to be sharp anyway. That may mean that some other part of the scene in the foreground will not be included in the one-third remaining depth of field and consequently will not be sharp.

Instead of focusing on infinity, if you focus on some object one-third of the way between you and the horizon, you will have brought forward the point on which you are focused and so increased the depth of field in the foreground of your picture. This new point of focus is called the hyperfocal distance.



Here a wide-angle lens was used with a small aperture to keep everything in the foreground and background in focus. The flowers are on Pike's Peak, over 14,000 feet up in the Rocky Mountains of Colorado.

How To: Increasing Depth of Field

- Photograph in bright sun so the aperture closes down.
- Zoom the lens out to a wider angle of view.
- Move farther away from the subject.
- Switch to aperture priority mode and select a small aperture such as f/11. (See Topic 0-0.)

How To: Using Focus Lock for Maximum Depth of Field

1. Point the camera so the area you want to focus on is in the focus area in the center of the viewfinder. In a landscape, pick something about one-third of the way between you and the horizon. For other scenes, pick something to focus on that's one-third of the way back from the nearest point you want to be sharp.
2. Press the shutter-release button down halfway and hold it there to lock in the focus.
3. Recompose the scene and press the shutter-release button the rest of the way to take the picture.

4.7 USING SELECTIVE FOCUS

Imagine you are photographing a scene something like the one below. Which part of the scene are you most interested in? Chances are it's the cattails and not the objects in the background. One way to make something stand out is to photograph it so it will be sharper than its surroundings. When everything in a picture is equally sharp, the viewer tends to give equal attention to all parts of the scene. But if some parts are sharp and others are not, the eye tends to look first at the sharpest part of the image.

You can selectively focus the camera and your viewer's attention on the most important part of the scene if you restrict the depth of field so that the significant elements are sharp while the foreground and background are less so.



Here the foreground is in sharp focus but the background is soft.

How To: Using Focus Lock for Minimum Depth of Field

1. Zoom the lens in to magnify the subject or move close to it and focus the camera on, or slightly in front of, the subject you want sharpest.
2. Press the shutter-release button down halfway and hold it there to lock in the focus.
3. Recompose the scene and press the shutter-release button the rest of the way to take the picture.

How To: Decreasing Depth of Field

- Photograph in dim light to open up the aperture.
- Zoom the lens in to enlarge the subject.
- Move closer to the subject.
- Switch to aperture priority mode and select a large aperture such as f/4. (See Topic 0-0.)

4.8 CONVEYING THE FEELING OF MOTION

Blur can contribute a feeling of motion in the image that may be missing from a more static shot. A slow shutter speed or one of the other techniques described here causes a moving subject to move across the image sensor during the exposure causing a blur can clearly say: Motion! These techniques often work best with a long lens or a big subject so the subject doesn't look too small in the image. One place to begin is to shift to shutter-preferred mode and pick a slow shutter speed. You can use this setting to deliberately blur moving objects such as running water.

Panning the camera in the same direction as a moving subject produces an image where the subject is relatively sharp against a blurred background. Your movement should be smooth and controlled to get a good pan, so begin to pan the camera before the subject enters your viewfinder. Smoothly depress the shutter release as you follow the motion of the subject, keeping it in the same position in the viewfinder. Follow through as you would in golf or tennis. Panning takes practice so take as many images as you can and erase those that don't work. Results are quite unpredictable here because your body motion adds yet another variable to the final picture.



Panning the camera as this young great blue heron took off blurred the background.

How To: Conveying Motion

- Try blurring images in low-light situations. In bright light, the shutter will open and close too fast.
- Switch to shutter priority mode and select a slow shutter speed. (See Topic 0.0.)
- In some situations, you may want to turn the flash off when trying to blur nearby subjects. (See Topic 0.0.)

CHAPTER 5, CONTROLLING EXPOSURE



Objectives

- Describe how your meter works
- Explain how exposure affects your images
- Explain when automatic exposure works well
- Describe when to override automatic exposure
- Describe how to override automatic exposure
- Explain how to control brightness and contrast

Introduction

Automatic exposure control is one of the most useful features of your camera. The convenience of having the camera automatically measure the brightness of the light, then set the correct shutter speed and aperture will be particularly evident to you if you have ever used a camera that did not function automatically in that way. It means you can often let the camera deal with the exposure while you concentrate on the image. This is especially helpful when photographing action scenes where there isn't time to evaluate the situation and then set the controls manually.

You shouldn't, however, always leave the exposure to the automatic system. Automatic exposure works well in most, but not all, lighting conditions. At times the lighting can fool

any automatic exposure system into producing an underexposed (too dark) or overexposed (too light) image. Although you can make adjustments to a poorly exposed image in a photo-editing program, you've lost image information in the shadows or highlights that can't be recovered. You will find it better in some situations to override the automatic exposure system at the time you take the picture.

Typical situations in which you might want to override automatic exposure include interesting and unusual lighting situation. For example, if you want to photograph into the sun, record a colorful sunset, show the brilliance of a snow-covered landscape, or convey the dark moodiness of a forest, you will probably need to adjust exposure, rather than let the camera make exposure settings automatically.

5.1 HOW YOUR METER WORKS

All light meters, including the one built into your digital camera, operate on the same general principles. A light-sensitive photocell regulates the amount of electricity flowing in the metering system. As the intensity of the light reflected from the subject changes, the amount of electricity flowing through the photocell's circuits changes and is used by the autoexposure system to calculate and set the shutter speed and aperture.

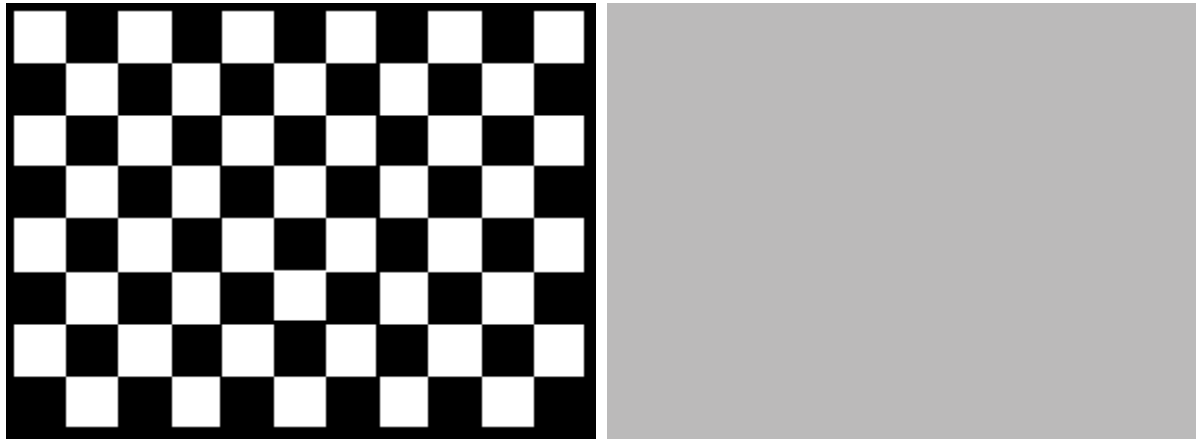
Your camera's meter measures light reflecting from the part of the scene shown in the viewfinder or on the LCD panel. The coverage of the meter (the amount of the scene that it includes in its reading) changes just as your viewfinder image changes, when you change your distance relative to the scene or when you zoom the lens. Suppose you move close or zoom in and see in your viewfinder only a detail in the scene, one that is darker or lighter than other objects nearby: the suggested aperture and shutter speed settings will be different than if you meter the scene overall from farther away.

Meter Averaging and Middle Gray

Your exposure meter doesn't "see" a scene the same way you see it. Its view is much like yours would be if you were looking through a piece of frosted glass.



Your meter sees scenes as if it were looking at them through a piece of frosted glass. It doesn't see details, just averages.



Where you see a black and white checkerboard (left), your camera sees only an average gray (right).

Every scene you photograph is something like a checker board (left), but even more complex. Portions of it are pure black, pure white, and every possible tone in between. Regardless of the elements making up the scene, your camera's meter can average and measure brightness only.

The exposure meter and exposure control system in an automatic camera can't think. They do exactly what they are designed to do and they are designed to do only one thing. Regardless of the scene, its subject matter, color, brightness, or composition, the meter measures the overall amount of light reflecting from the scene. Since the light meter measures only brightness (how light or dark the scene is) and not color, the automatic exposure system then calculates and sets the aperture and the shutter speed to render this level of light as "middle gray" in the photograph. Most of the time this works very well because most scenes have an overall reflectance that average out to middle gray. But some scenes and situations don't average out to middle gray and that's when autoexposure will lead you astray.

A continuous spectrum of tones, ranging from pure black at one end to pure white at the other is contained in most scenes. In simple terms, this continuous scale can be thought of as dividing into a series of individual tones called a gray scale. Each of the tones in this scale has received 1 stop more exposure than the next darkest tone in the series, and one stop less exposure than the next lightest tone. The tone in the middle is called middle gray. A subject uniformly of this tone reflects exactly 18% of the light falling on it.



The gray scale is a series of steps reflecting different levels of brightness.

When you photograph a subject with an overall tone of middle gray, your camera's autoexposure system will set an exposure so that the subject will appear in the final image as middle gray. When you photograph subjects that have an overall tone lighter or darker than middle gray they will also be middle gray in the final image and therefore look too light or dark. As a result, if you photograph first a white card, then a gray card, and third a black card, and each completely fills the viewfinder frame when the exposure is calculated, each of the cards will be middle gray in the captured image.

in real life, you have to use exposure compensation or some other form of exposure control to lighten or darken the picture.

Types of Metering

All parts of a scene are usually not equally important when determining the best exposure to use. In a landscape, for instance, the exposure of the foreground is usually more important than the exposure of the sky. For this reason some cameras offer more than one metering method. The choices might include the following:

- **Matrix metering** divides the image area into a grid and compares the measurements against a library of typical compositions to select the best possible exposure for the scene.
- **Center-weighted** meters the entire scene but assigns the most importance to the center quarter of the frame where the most important objects usually are located.
- **Bottom-weighted** meters the entire scene but assigns the most importance to the bottom of the frame where the most important objects usually are located.
- **Spot** evaluates only the area within a small area in the middle of the viewfinder. This allows you to meter just a specific part of the scene instead of relying on an average reading. This mode is ideal when photographing a subject against a bright or dark background.

Meter weighting can cause a few problems. For instance, a dark object located off center against a very light background may not be exposed properly because it is not located in the area the meter is emphasizing. Or, in some cases, holding the camera vertically may give undue emphasis to one side of the scene. These occasions are uncommon, but when they occur you can ensure accurate readings and exposure settings by metering the subject from close-up. The camera settings can then be overridden if necessary to produce a well-exposed photograph.



In this image, automatic exposure worked well because the scene averages out to middle gray.

5.2 HOW EXPOSURE AFFECTS YOUR IMAGES

When you take a photograph, the exposure isn't uniformly distributed over the sensor's surface—unless you are photographing a subject that is absolutely uniform in tone. Highlights (brighter areas) in the scene reflect the most light, and the areas of the sensor onto which they are focused are exposed a great deal. Darker areas, like shadows, reflect much less light, so the areas of the sensor onto which they are focused receive much less exposure. The perfect exposure retains details in both the highlights and shadows. For the autoexposure system, this is as difficult as your parking a very large car in a very small garage. If there is even a little too much exposure, the image is too light and details are lost in the highlights. If there is too little exposure the image is too dark and details are lost in the shadows.

One way to ensure you get the best exposure is to take three pictures. The first would be at the recommended setting. The second would be lighter and the third darker than the original one. This process is referred to as bracketing because you're bracketing the suggested exposure. You can do this using exposure compensation (see Topic 0.0).



In this series of photographs you can see the effect of exposure on the image. The middle photo is correctly exposed. The left photograph was overexposed and is too light. The right photo was underexposed and is too dark.

5.3 WHEN AUTOMATIC EXPOSURE WORKS WELL

Most scenes that you photograph have an overall brightness of middle gray. Some areas of the scene may reflect 90% of the light and other parts may reflect 5%, but overall the average amount of light reflecting from the scene is 18%, the amount reflected by a middle gray subject.

Whenever you photograph a normal scene with this average brightness, your automatic exposure system exposes it correctly. Typical middle gray scenes include the following:

- Scenes in bright sunlight where the subject is front-lit by a sun that is behind you when you face the scene.
- Scenes on overcast days or under diffused light, such as in the shade or in evenly lit scenes indoors.



This image has detail in the lightest (highlight) and darkest (shadow) areas. If just a little darker or a little lighter details would be lost in the shadows or highlights.

How To: Taking a Picture in Automatic Mode

1. Turn the camera on and set it to automatic mode. Be sure to remove the lens cap.
2. 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.
3. Press the shutter-release button halfway down so the camera can set focus, exposure, and white balance. When the camera has done so, a lamp may glow or the camera may beep.
4. Press the shutter-release button all the way down to take the picture. When you do so, the camera may beep. The camera then saves the new image onto the camera's flash card.
5. When done, turn the camera off.

5.4 WHEN TO OVERRIDE AUTOMATIC EXPOSURE

Let's take a look at some of the most common situations where your automatic exposure system will have problems. It's in these situations where you'll need to override the suggested exposure settings.

Scenes Lighter than Middle Gray

Scenes lighter than middle gray, such as beach scenes, or bright sand or snow covered landscapes, reflect more than 18% of the light falling on them. The autoexposure system doesn't know the scene should look bright so it calculates an exposure that produces an image that is too dark. To lighten the image so it matches the original scene, you must override the camera's automatic exposure system to add exposure.



The snow scene here is typical of scenes that are lighter than middle gray. Most of the important tones in the scene are at the lighter end of the gray scale. The overall "average" tone would be about one stop brighter than middle gray. For a good picture you have to increase the exposure by one stop (+1) to lighten it (left). If you didn't do this, the snow in the scene would appear too gray (right).

Scenes Darker than Middle Gray

Scenes that are darker than middle gray, such as deep shadows, dark foliage, and black cloth, reflect less than 18% of the light falling on them. Although such scenes are not as common as scenes lighter than middle gray, you will come across them occasionally. If you photograph such scenes using automatic exposure, they will appear too light. The meter cannot tell if the scene is dark or just an ordinary scene with less light falling on it. In either case it increases the exposure to make the scene lighter. When it does this, it overexposes the image and makes it too light. To produce a picture with an overall tone darker than middle gray, you need to override the autoexposure system to decrease the exposure to make it darker.



The black cat is between one and two stops darker than middle gray. To darken the scene so the cat's not middle gray, exposure must be decreased by one (-1) or two (-2) stops.

Subject Against Very Light Background

Subjects against a very light background such as a portrait against a bright sky or light sand or snow, can confuse an automatic exposure system, particularly if the subject occupies a relatively small part of the scene. The brightness of the background is so predominant that the automatic exposure system reduces the exposure to render the overall brightness as a middle gray. The result is an underexposed and too-dark main subject.



Here the scenes were underexposed to silhouette the people in the foreground. To show detail in the people, exposure would have had to have been increased two stops (+2).

Subject Against Very Dark Background

When a small light subject appears against a large dark background, your autoexposure system assumes the overall tone to be darker than it actually is, because so much of the scene is dark compared to the smaller brighter main subject. The autoexposure system increases the exposure to produce a middle tone. The result is an overexposed and too light main subject.



The rising sun illuminated only one boat in this harbor scene. If the exposure hadn't been reduced by two stops (-2), the background would be too light and the white boat would have been burned out and too white. A scene like this is a great place to use spot metering (See Topic 0.0.)

Scenes with High Contrast

Many scenes, especially those with brightly lit highlights and deep shadows, have a brightness range that cannot be completely recorded on an image sensor. When confronted with such scenes, you have to decide whether the highlight or shadow area is most important, then set the exposure so that area is shown accurately in the final picture. In high contrast situations such as these, move close enough so the most important area fills the viewfinder frame. Use exposure lock (see Topic 0-0) from that position to lock in the exposure. Another way to deal with high contrast is to lighten the shadows by adding fill flash. A portrait, for example, lit from the back or side is often more effective and interesting than one lit from the front. But when the light on the scene is contrasty, too much of the person's face may be in overly dark shadow. In this case use fill flash (see Topic 0-0) or a white reflector card to fill and lighten the shadows.

TIP

In high contrast settings, some cameras let you decrease contrast at the time you take the picture. (See Topic 5.0.)



The archway was in the shadows and dark while the cathedral was brightly lit by the sun. Both couldn't be exposed properly, so the archway was left as a solid black.

Hard to Meter Scenes

Occasionally it's not convenient or even possible to meter a scene. Neon street signs, spotlit circus acts, fireworks, moonlit scenes, and many similar situations are all difficult and sometimes impossible to meter. In these cases, it's easiest simply to experiment, using the exposure compensation control on your camera (see Topic 0.0). After taking a picture at the suggested exposure, you use exposure compensation to take other exposures both lighter and darker than the suggested settings.



This scene has a bright sky and one brightly illuminated fisherman against a dark background. A scene such as this is hard to meter because of the variety of lighting.



*A relatively
small subject
against a
wide expanse
of sky will
almost always
be
underexposed
unless you use
exposure
compensation.*

5.5 HOW TO OVERRIDE AUTOMATIC EXPOSURE

Most digital cameras provide one or more ways to override the automatic exposure system to get the exposure you want.

Exposure Compensation

Exposure compensation lets you lighten or darken the photograph that the camera would produce if operated automatically. To lighten a picture, you increase the exposure; to darken one, you decrease the exposure. The amount you increase or decrease the exposure is specified in "stops." For example, to increase the exposure 1 stop, you specify +1 to open the aperture or slow down the shutter speed. It's easy to use exposure compensation because you can preview your changes on the LCD monitor.



Exposure compensation darkens or lightens pictures.

Tip

Use + exposure compensation when the subject is bright and - when it's dark

To make changes to exposure, you use exposure compensation control where you can often increase or decrease exposure by two stops in one-third stop increments. Here are some typical settings where you'd make these changes.

- +2 is used when the light is extremely contrasty and important shadow areas are much darker than brightly lit areas.
- +1 is best for sidelit or backlit scenes, beach or snow scenes, sunsets and other scenes that include a bright light source, or very light objects, such as a white cat on a white pillow.

- 0 (the default) is best for scenes that are evenly lit and when important shadow areas are not too much darker than brightly lit areas.
- -1 is for scenes where the background is much darker than the subject, such as a portrait in front of a very dark wall. Also good for very dark objects, such as a black cat on a black pillow.
- -2 is for scenes of unusual contrast, as when an extremely dark background occupies a very large part of the image and you want to retain detail in the brighter parts of the scene.

Exposure Lock

Just as you can point the camera at an object and press the shutter-release button halfway down to lock in focus, so you can with exposure. For example, with a gray barn sitting in a white snow-covered field, you can use spot metering or move closer to meter just the barn and hold down the shutter-release button to lock in that reading. You can continue holding the button half way down and recompose the picture using the locked in exposure and focus setting.

How To: Using Exposure Lock

1. Point the camera so the subject that you want to lock exposure on is in the focus area in the center of the viewfinder.
2. Press the shutter-release button down halfway and hold it there to lock in the exposure.
3. Without releasing the shutter-release button, recompose the scene and press the shutter-release button the rest of the way to take the picture.

5.6 CONTROLLING BRIGHTNESS AND CONTRAST

Some cameras let you adjust the contrast and brightness in your photographs; also referred to as adjusting the tone curve. To visualize the effects these controls can have, adjust the brightness and contrast settings on your TV or computer monitor. Some cameras allow you to adjust brightness and contrast at the time you take a picture. With others, you can only do it later using a photo-editing program.

Brightness

Brightness raises or lowers the brightness of the entire scene to make everything lighter or darker.



Decreasing brightness darkens an image (left) while increasing it lightens it (right).

Contrast

Contrast adjusts the differences between the brightest and darkest areas in the image. You can increase or decrease the contrast.



Decreasing contrast makes colors in the image look more muted and "flatter" (left) while increasing it makes it look sharper and crisper (right).

CHAPTER 6, CAPTURING LIGHT & COLOUR



Objectives

- Explain where color comes from
- Describe what color balance is and how it affects images
- Explain how color balance is affected by the time of day
- Describe how color balance is affected by the weather
- Describe some of the important things to know about photographing at night
- Explain how the direction of light affects images
- Describe how direct and diffuse light affect images
- Using Light & Color Creatively

Introduction

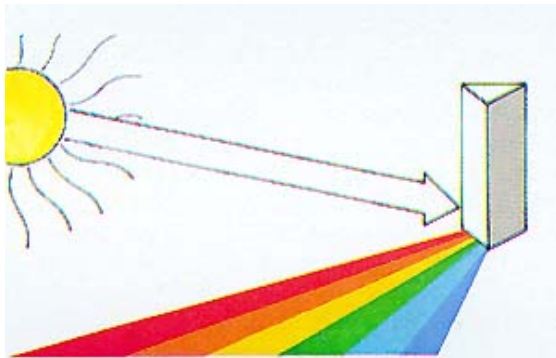
Image sensors in digital cameras are designed to produce colors that match those in the original scene. However, there is a lot of variation among sensors and among the circuits and software that process raw images into final photographs. The results you get depend, in part, on the accuracy with which you expose the image and the match between the color balance of the sensor and the color balance of the light illuminating your subject.

With film cameras, photographers usually explore a wide variety of films before settling on the one or two they like best. This is because each film type has its own unique characteristics. In some the grain is small, in others it's larger. A film may have colors that are warmer than other films, or slightly colder. These subtle variations among films are slight but noticeable and photographers gravitate to one or the other. With digital cameras, you don't have the same choice offered by film cameras. The "film" in the form of an image sensor is built into your camera. Whatever its characteristics are, they are the characteristics you have to live with until you buy another camera.

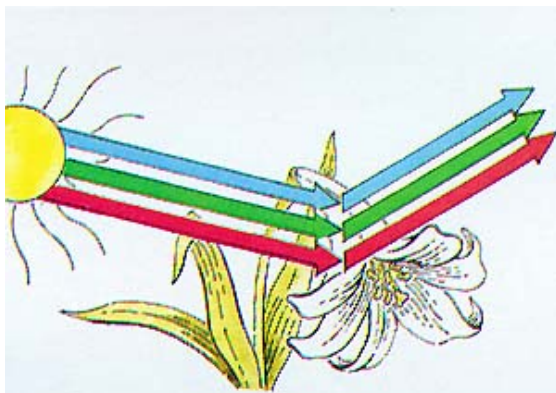
In this chapter, we explore the world of color and how you manage it in your photos.

6.1 WHERE DOES COLOR COME FROM?

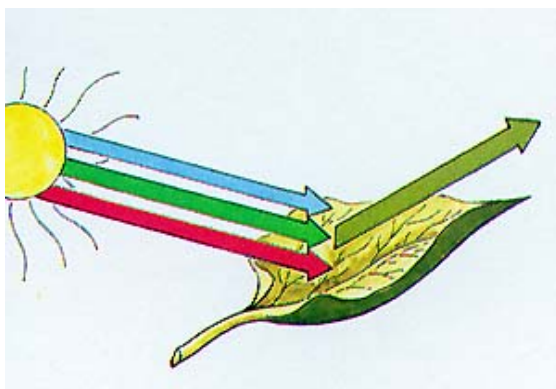
Why do we see colors? Light from the sun or from a lamp seems to have no particular color of its own. It appears simply to be "white" light. However, if you pass the light through a prism, you can see that it actually contains all colors, the same effect that occurs when water droplets in the atmosphere separate light into a rainbow. A colorful object such as a leaf appears green because when white light strikes it, the leaf reflects only the green wavelengths of light and absorbs the others. A white object such as a white flower appears white because it reflects most of the wavelengths that strike it, absorbing relatively few. Inks, dyes, or pigments in color prints also selectively absorb and reflect certain wavelengths of light and so produce the effect of color.



Although light from the sun appears colorless or "white," it actually contains a range of colors similar to a rainbow. You can see these colors using a prism to separate them out.



White objects reflect most of the wavelengths of light that strike them. When all of these wavelengths are combined, we see white. On the other hand, when all of them are absorbed, and none reflected, we see black.



A green object such as a leaf reflects only those wavelengths that create the visual effect of green. Other colors in the light are absorbed by the leaf.

6.2 COLOR BALANCE

Although light from the sun or from a light bulb looks white to us, it not only contains a mixture of all colors, it contains these colors in varying proportions. Light from the midday sun, for example, is much bluer than light from a sunrise or a tungsten lamp. To produce what appears to us to be normal or accurate color balance, the image we capture must contain the colors in the original scene. These colors are affected by the color of the light source.

One way to describe the color of a light source is by its color temperature. The color temperature scale is calibrated in degrees kelvin, somewhat like a thermometer that calibrates heat temperatures in degrees centigrade. The color temperature scale ranges from the lower color temperatures of reddish light to the higher color temperatures of bluish light. Daylight contains proportionately more light toward the blue end of the spectrum. Incandescent light contains more toward the red end. That's why we describe daylight as "cooler" and incandescent light as "warmer."



"White" light actually contains light of different colors and in different proportions. The overall color cast of the light changes as the proportions of the colors change. Although different white light sources have different "colors" you don't see the subtle differences because your brain compensates automatically.

Image sensors can be balanced to match light of a particular color temperature. This is done using a system called white balance that automatically or manually adjusts the sensor's relative sensitivity to different colors in order to match the overall color cast of the light it's recording. The daylight (or outdoor) setting matches the cooler, more bluish color of daylight. The incandescent (or indoor) setting matches the warmer, more reddish color of studio lights.



Daylight



Fluorescent



Incandescent

You can preview color balance by looking at a scene in the LCD monitor. You can also check the color balance of any image you've already taken the same way. If you examine the images closely you may notice that white areas in particular have some color cast to them. If so, you may want to adjust white balance for subsequent shots. Many digital cameras offer a number of white balance settings, some for specific lighting situations.

- **Auto** (the default) works in a wide variety of lighting conditions.
- **Manual** lets you set white balance manually by aiming the camera at a piece of white paper.
- **Sunny** is best when photographing outdoors in bright sunlight.
- **Incandescent** or tungsten is best when photographing indoors under incandescent lights.
- **Fluorescent** is best when photographing indoors under fluorescent lights.
- **Cloudy** is best when photographing outdoors in cloudy or overcast conditions.
- **Flash** is best when photographing with flash.

6.3 COLOR BALANCE AND TIME OF DAY

In photography, there is a color of light called "daylight." However, this type of light occurs only at a specific time of day. Over the course of the day, the light can change from a warm red at sunset, to a cold blue at noon, and then back to a warm red or orange at sunset. "Daylight" on the color temperature scale is really set for midday sun between 10 A.M. and 2 P.M. During these hours, colors appear clear, bright, and accurately rendered in the photo.

Before and after midday, light from the sun is modified by the extra distance it travels through the Earth's atmosphere. Some of the blue light is filtered out, leaving the light with a more reddish cast than at midday. This is easily seen very early or late in the day when the light is often quite red-orange in tone. The change in color will affect your pictures strongly, but this reddish cast is a wonderful light to photograph in.



Just before dawn and at dusk, colors often appear muted or monochromatic. During these hours when light is relatively dim, you often have to use an extra-long exposure time.



Midday light on a sunny day will produce colors that appear natural and accurately rendered.



Early morning and late afternoon light outdoors will produce a warmer, more reddish color balance than you will get at midday.

Sunsets and Sunrises

Sunsets and sunrises are relatively easy to expose because the exposure is not as critical as it is with some other scenes. If you underexpose the scene slightly, the colors will simply be a bit richer and darker. Slight overexposure will make the same scene slightly lighter.



The sun often takes on a flattened appearance as it rises above the horizon. When partially obscured and softened by a haze, its warm, red glow illuminates the foreground.



Sunrises and sunsets by themselves aren't very interesting. It's objects in the foreground, such as the skyline, or unusual atmospheric effects such as this dark cloud that give them some punch.

The colors in the sky are often richest in the half hour before the sun rises and the half hour after it sets. It pays to be patient as you watch the sky change during these periods. For one thing, the sun itself is below the horizon and not in the image so exposure problems are greatly reduced. Also, clouds in the sky often light up dramatically and in some cases, reflect the light to other clouds until you find yourself under a wonderful canopy of reflected color.

Every sunrise and sunset is unique and the variations can be truly amazing. It's certainly not true that "if you've seen one sunrise or sunset, you've seen them all." If you want the sun in the photo, it's best if it is softened and partly obscured by a mist or haze. If it rises as a hot white or yellow ball, find another subject, or turn around and photograph the scene it's illuminating.



With the bright disk of the sun included in a sunset or sunrise, your picture may come out somewhat underexposed and darker than you expected it to be. Add 1 or 2 stops of exposure to a sunset or sunrise that includes the disk of the sun.

It's tempting to take all of your photos of a rising or setting sun, but it often pays to turn around. The rich, warm light changes the colors of everything it hits. This is a magic time to capture images that will really stand out. Colors take on a warm, soft glow that can't be found at any other time of the day.



Instead of shooting into the sun at sunrise or sunset, shoot with it behind you to capture rich, warm colors of scenes bathed in the sun's light.



A long-focal-length lens will enlarge the disk of the sun so that it becomes a more important part of the picture. Foreground objects silhouetted against the bright sky, can also add interest.



Here the camera was positioned so the rising sun was behind one of the grain elevators and wouldn't burn out the image with its glare.

Anticipating the Sun and Moon

When planning to integrate the sun or moon into an image it helps to know when it rises or sets. With the moon, it also helps to anticipate the phase. This information is available in almanacs, and also on the Web at the U.S. Naval Observatory (<http://aa.usno.navy.mil/AA/data/>). You can view the phase of the Moon at

<http://tycho.usno.navy.mil/vphase.html>.

The Moon

The moon, especially when full, adds a lot to an image. The best time to capture the moon is when it's near the horizon. Because it is close to foreground objects at that time, it looks much larger than when it's higher in the sky.

Keep in mind that the moon is relatively dim and usually requires long exposures. Since it's moving relative to the Earth, longer exposures can actually blur it, giving it an oblong shape. To reduce the chances of this happening, shoot just before sunrise or just after sunset when there is still some light in the atmosphere from the recently set sun. (It bends around the Earth's curvature due to refraction in the atmosphere.)



The rising full moon, and the trail it leaves across the water, adds a lot to this photo of an old-fashioned coal-burning power plant on Salem Harbor.



Long exposures on bright moonlit nights can be very attractive. Just keep in mind that the moon does move so exposures longer than a minute or so may show it elongated.

6.4 COLOR BALANCE AND WEATHER

There's no need to leave your camera home just because the sun hasn't come out. In fact, rain, snow, fog, and mist can add interest to your pictures. Objects at a distance often appear diffused and gray in such weather, with foreground objects brighter than normal because they are seen against a muted background. Remember to take a little extra care in bad weather to protect your camera against excessive exposure to dampness.



Snow covered scenes are not only beautiful to look at, they make great photographs.



Even a light fog subdues colors and softens objects in the background.

Rainbows always make good pictures. The problem is, you rarely find them where you want them, when you want them. To get better at capturing them, you should know something about how they form so you can anticipate them. Rainbows are formed by sunlight being refracted by raindrops. You'll usually find the combination of rain and sun at the leading or trailing edge of a summer storm. You can't see rainbows at all times of the day. To understand why, visualize the way the rainbow works. If you stand with your back to the sun while looking at a rainbow, imagine a line from the sun passing through your eye, through the Earth, and out into space. (This is called the antisolar point.) The rainbow forms a complete circle around this imaginary line, however from ground level part of it is always below the horizon. A line drawn from your eye to the top of the rainbow forms a 42-degree angle with the imaginary line from the sun through your eye. (If there is a secondary rainbow, it forms an angle of 51-degrees.) Because these angles determine the position of the rainbow in the sky, it will sink as the sun rises and rise as the sun sinks. At some points, the entire rainbow, not just the bottom half, will be below the horizon where you can't see it. That's why you'll never see a rainbow at midday.



From a plane you can sometimes see all 360-degrees of a rainbow. Here you see a section of one shot through an airliner window. To the right of the brighter primary rainbow is a dimmer secondary one.



Even a light fog subdues colors and softens objects in the background.



A very light mist can dim the sun enough to include it in a photograph. If it weren't partially obscured by the fog, it would appear as a white dot against a very dark background.



On the coldest days of the year "sea smoke" forms over the ice-cold water. Here it surrounds a lobster boat and is backlit by the rising sun.



As a summer storm moves in, there are often times when the background is almost black with the sun shining on objects in the foreground. The contrasts can be very dramatic.



Storms are not a time to hide in the house, they are a time to get out and watch the light. As storms approach and recede, or when there are breaks in the clouds, you find some of the most interesting, at times almost surrealistic light. It's a time of muted contrasts but rich colors—a perfect environment for interesting photos.

6.5 PHOTOGRAPHING AT NIGHT

You can photograph many different things outdoors at night, so don't put your camera away just because the sun is gone for the day. Light sources (street lights, automobile lights, neon signs, or fires) or brightly lit areas (illuminated buildings or areas under street lights) will dominate pictures at night because they stand out strongly against darker backgrounds. Plan to use these bright areas as the dominant part of your picture. A tripod will support your camera during long exposures and prevent blur caused by camera motion during the time the shutter is open.



This exterior of the Paris Opera House was shot at night with just illumination from spotlights.

To capture interesting images of fireworks, put people or water in the foreground. It also helps if there are identifiable objects in the image such as an illuminated building or monument to give the viewer a sense of place. Get upwind from the show since fireworks generate a lot of smoke that can become a problem if you are downwind. If you are upwind, the smoke will become part of the image, illuminated by the fireworks. Automatic exposure doesn't work well with fireworks. Try a series of exposures of different bursts because there is a certain amount of luck involved. You might also use flash to illuminate foreground figures.

Set your exposure for fireworks by switching to aperture or shutter preferred mode and try for a setting of $f/2.8$ at $1/30$ sec. You might also want to try increasing sensitivity, use exposure compensation, and try different combinations of aperture and shutter speed as well as those recommended here.



Fireworks can be dramatic, but are difficult to capture. You need to experiment and a digital camera is perfect for that because you can instantly review your results.



Candlelight provides a very warm glow to whatever it illuminates.



Use automatic exposure at night if brightly lit areas take up most of the scene visible in your viewfinder. If they do not, use exposure compensation to reduce the exposure and darken the image so bright lights aren't overexposed.



This picture of Chicago was taken just after sunset through an airliner window. A few minutes later the scene was too dark to capture without blurring due to long exposure times.



The U.S. Constitution lies floodlit in Marblehead Harbor.



There is a time at twilight and dawn where there is enough light in the sky so it has the same tonal value as the foreground.

6.6 LIGHT: ITS DIRECTION

The direction that light is coming from relative to your camera's position is important because it affects the shadows that will be visible in your picture. Four main types of lighting are illustrated here: front-lighting, side-lighting, backlighting, and top-lighting. Notice the position of the shadows in these photographs and how they affect the subjects.

The direction of light can affect your automatic exposure. Backlighting, for example, can leave your subject silhouetted against a background so bright that your automatic exposure system will assume the subject is much brighter than it actually is, and so underexpose the scene and make the subject even darker. This is fine, if you want a silhouette. If you don't, you should use exposure compensation to lighten the image.



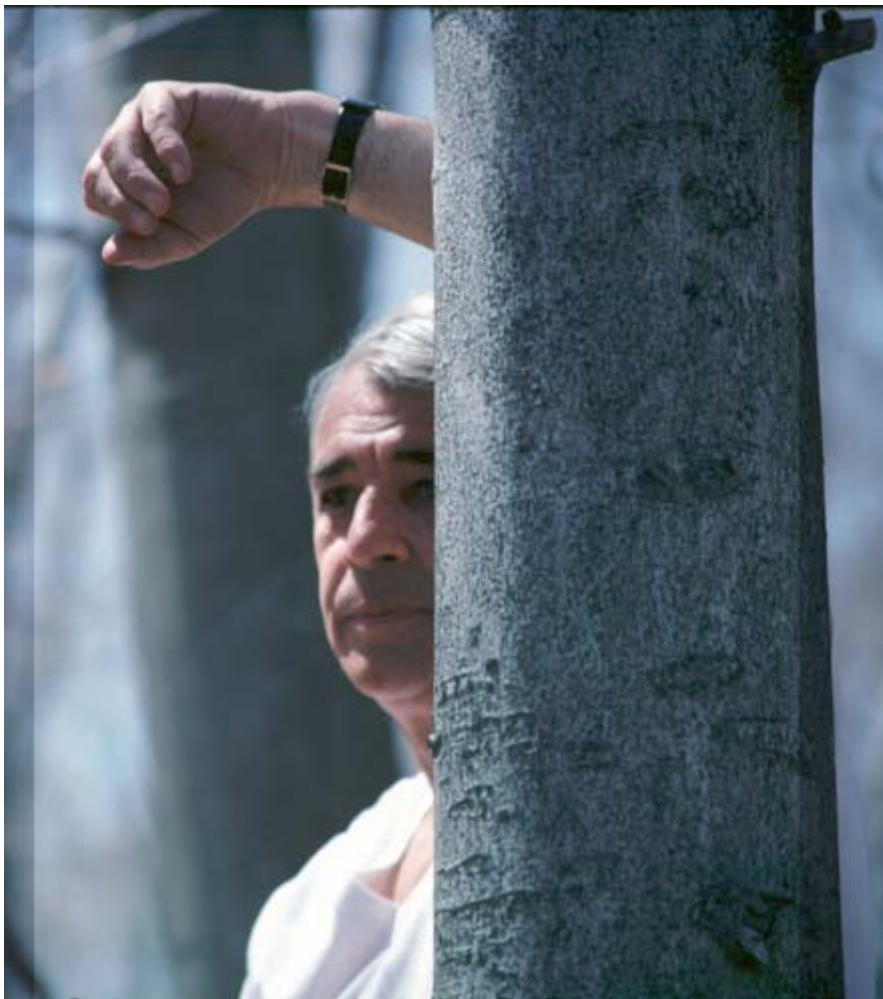
Side-lighting, light that falls mainly on one side of the subject, increases the sense of texture and volume because such cross-lighting casts shadows visible from the camera's position that emphasize surface details. Landscape photographers often prefer to work early in the morning or late in the day because the sun low in the sky will sidelight scenes and add interesting surface textures.



Front-lighting, light that falls on the subject more or less from the camera's position, decreases visible shadows and so minimizes surface details such as skin texture. Front-lighting also tends to minimize the apparent roundness or volume of the subject.



Backlighting, light that comes from behind the subject, puts the side of the subject that is facing the camera in shade. Automatic exposure tends to make backlit scenes too dark. You can add exposure to lighten the picture, especially those parts that are in shade.



Top-lighting, light that comes from more or less overhead, can occur outdoors at noon or indoors in public buildings or other places where ceiling lights

predominate. If you are photographing a person, you will notice that top-lighting tends to cast shadows in eye-sockets and illuminate the top of the nose brightly. To avoid this effect, you might try moving the person into the shade.



Top-lighting, such as that found at midday, can selectively illuminate things, such as this flag in the guy's back pocket, that would be in shadow with light coming from a lower angle.

6.7 LIGHT: FROM DIRECT TO DIFFUSE

Light not only has direction, it can be direct or diffused. Direct light, light coming mainly from one direction, produces relatively high contrast between bright highlights and dark shadows. Diffused light bounces onto the subject from several directions, lowering contrast. Contrast, in turn, affects the brilliance of colors, the amount of visible texture and detail, and other visual characteristics.

In direct light you may have to choose whether you want highlights or shadows to be correctly rendered because image sensors can accurately record only a limited range of contrast between light and dark areas. If this creates a problem because both highlights and shadowed areas are important, you can sometimes add fill light to lighten shadows and decrease contrast or adjust the contrast setting (see Topic). In diffused light, colors tend to be softer than in direct light and textures are also softened because shadow edges are indistinct.



Direct light comes from a point source, such as the sun on a clear day. Direct light produces dark, hard-edged shadows that crisply outline details. Here the light and shadows almost form an abstraction.



Diffused light comes from a light source that is so large relative to the subject that it illuminates from several directions. On a hazy or overcast day, illumination comes from the entire dome of the sky, not from the brighter, but smaller, sun. Indoors, light bounced into an umbrella reflector or onto a wall or ceiling creates a broad source of light that wraps around the subject.



On a foggy or hazy day, objects in the foreground tend to stand out sharply against a background that is partially obscured by light reflecting from the atmosphere. You can emphasize this effect by increasing the exposure a stop or so more than recommended by your autoexposure system.



When the sky is overcast, yet still bright, interior rooms are flooded with a soft, even lighting.

CHAPTER 7, LENSES



Objectives

- Describe how a lens works
- Explain lens focal length and its affect on angle of view
- Describe zoom lenses
- Explain the characteristics of a normal lens
- Explain the characteristics of a wide-angle lens
- Explain the characteristics of a telephoto lens
- Describe how lens focal length affects portraits
- Explain perspective: how a photograph shows depth

Introduction

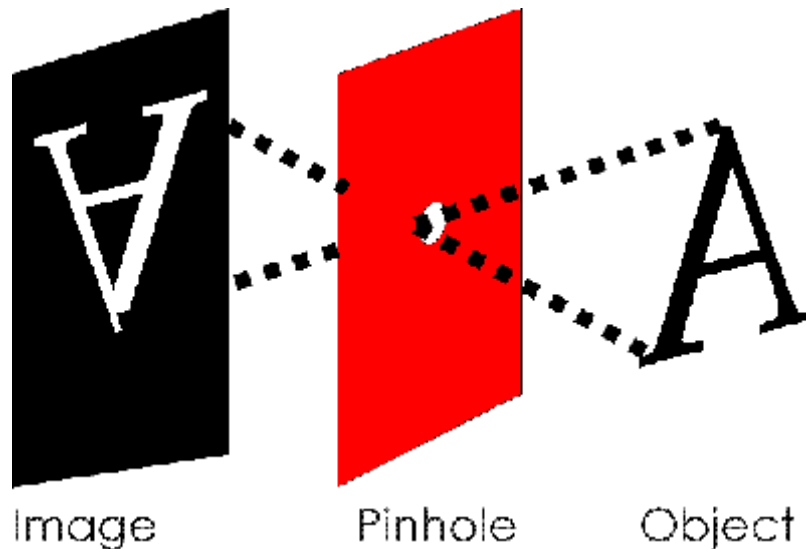
Many digital cameras come with zoom lenses so you can zoom in or out to meet different photographic opportunities. Zoom in on a subject and you can capture distant action at sporting events or in the field. Zoom out and you can capture a wide-angle view of a large group, a roomy interior, or of an expansive landscape. The ability to change your angle of view as you frame your image is one of your most powerful creative controls.

Modern camera lenses are designed on computers, ground to critical tolerances, coated with chemicals to improve light transmission, and then mounted in precision barrels and mounts. These lenses have excellent speed and sharpness, much more so than lenses of just a few years ago. The primary function of a lens is to gather light reflecting from a scene and focus that light as sharply as possible onto the image sensor in the camera. A high-quality lens does this very well, but to get the most out of what it has to offer you should know a few of its characteristics and how they affect your images.

Although your camera is equipped only with a zoom lens, in this chapter we look at the effects it has when used as a normal, wide-angle, and telephoto lens. This approach gives you the background you need to use the lens effectively and creatively.

7.1 HOW A LENS WORKS

Surprisingly, lenses are not actually needed to take a picture. You can make a camera out of a shoe box with a small hole in one end. Known as a pinhole camera, this primitive device can actually focus an image and record it on film. To make a photograph, the box is loaded in the dark with a light-sensitive film or paper and the pinhole is covered with opaque tape. Peeling the tape back (much like a shutter) to uncover the pinhole (much like a lens aperture) begins the exposure, recovering the pinhole ends it. The exposed film or paper can be removed in a darkroom and the image developed.



In a pinhole camera, the light waves from the object converge on the pinhole and focus the image upside down on the film.

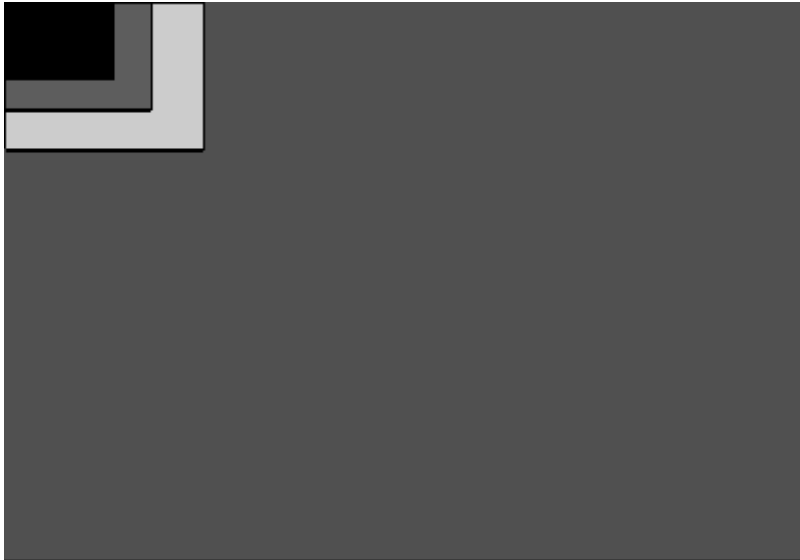
The Pinhole Visions (www.pinhole.com) web site provides information on pinhole photography, and the work of pinhole photographers.

Light is bent when it passes between substances having different densities. You can see this if you look at an object that is both in and out of water; for example a spoon in a glass half full of water looks bent at the point where it enters the water. Obviously, the spoon isn't bent; the light reflecting from the spoon is, as it passes from the dense water to the less dense air. The same effect occurs when light passes from the air through a piece of glass. If the glass is curved correctly, as it is in a camera lens, it can bend the light in such a way that an image of the scene in front of the lens is focused behind it.

The focal length of any lens is the distance between the optical center of the lens and the point at which it focuses an image. When you use a magnifying glass to focus the light from the sun onto a piece of paper, the area illuminated by the beam will become larger or smaller as you change the distance between the magnifying glass and paper. At the point where the bright circle of light is smallest (and where it might set the paper on fire), the simple lens that constitutes the magnifying glass is in focus. The distance between the magnifying glass and the paper is the lens' focal length.

Lens focal lengths are based on the physical characteristics of the lens so they are absolute values. However, a given focal length lens may be a wide angle lens on one camera and a telephoto lens on another. This is because descriptions such as "wide-angle" or "normal"

depend on the size of the film or image sensor being used. As these get smaller, a given focal length lens magnifies more. There are currently a number of differently sized image sensors used in digital cameras. For that reason, different focal lengths are needed to give the same image coverage on different cameras. Because of the confusion this causes, most digital camera companies give the actual focal length of their lenses and then an equivalent focal length were the lenses to be adapted to a 35mm camera. For example, a camera may list its lens as 7.5mm (equivalent to 50mm on 35mm camera). Because digital equivalents vary widely, we often use the more familiar 35mm focal lengths in this book.



In the upper left corner are shown some image sensor sizes. The larger rectangle is the size of a frame of 35mm film.

7.2 ZOOM LENSES AND FOCAL LENGTH

A zoom lens lets you choose any focal length within the range the lens is designed for. When you change focal lengths by zooming the lens, two important effects are immediately obvious in the lens' angle of view and its magnifying power.

Angle of view refers to how much of a scene the lens covers. Zoomed out using a shorter focal length, you have a wide-angle of view that captures a wide expanse of a scene. As you zoom in using a longer focal length, the field of view narrows and you can isolate small portions of the scene without moving closer to the subject.



Here you see the angle of view of various focal length lenses. The shorter focal length lenses are on the left and the longer ones on the right.

Magnification is related to the lens' angle of view. Since zooming out includes a wide sweep of the scene, all of the objects in the scene are reduced to fit into the image. Zooming in gives a much narrower angle of view, so objects in a scene appear larger.

Zoom lenses on digital cameras work much like those on camcorders. There are two buttons or a movable lever. Pressing one zooms in, increasing the focal length and narrowing the angle of view. Pressing the other zooms out, decreasing the focal length and widening the angle of view.



One of the best things about zoom lenses is the speed with which you can react to photo opportunities. Here, the key action in the scene on the top is lost in the large frame (left). By zooming in, this key action was isolated (right).

How To: Zooming the Lens

To use a zoom lens you press a lever or zoom-out button to widen the angle of view and a lever or zoom-in button to enlarge subjects. The viewfinder zooms along with the optical

zoom lens although it doesn't always show the entire picture area.

7.3 NORMAL LENSES

A "normal lens" for a 35mm camera usually refers to a lens with a 50mm focal length. On a digital camera, an equivalent lens will have a much smaller focal length because image sensors are much smaller than 35 mm film. When you zoom your lens and look at the image on the LCD monitor, the scene looks about the same as it does to the unaided eye. Looking at the LCD monitor with the lens zoomed all the way out makes everything appear closer than it actually is. With it zoomed out to a wide-angle, everything looks farther away.



A normal lens gives you the feeling that you're looking at the scene with your own eyes.

A normal-focal-length (50mm) lens isn't necessarily the one photographers normally to use. Many photographers prefer the wider angle of view and greater depth of field provided by a slightly shorter focal length.

Changing Apertures

A lens' maximum aperture is determined by dividing the actual diameter of the aperture opening into the focal length of the lens. That's why the aperture might change from f/2.6 when zoomed out to f/4 when zoomed all the way in on a subject.



It's hard to look at a photo and tell what focal-length lens was used to take it. However, objects in an image taken with a normal lens look normal in their spatial relationships.

See for Yourself

A lens is called normal because it captures a scene just as the human eye does. This seems to violate common sense, because the eye's angle of view is much wider than any normal lens. However, you can demonstrate for yourself why a specific focal length is normal for your camera. If you are a passenger in a car, try zooming the lens as you watch the traffic ahead on the LCD monitor. The longer focal lengths make distant cars appear right on top of you; in reaction you might even try to put on your brakes and then discover the cars are nowhere near as close as you thought. With shorter focal lengths, cars look far ahead, even when relatively close. A normal focal-length makes the cars appear in the same distance relationship as you perceive them ordinarily.

Another demonstration is to take two photographs of greatly different size and tape them to a wall. Look at them one at a time on the LCD monitor with the lens zoomed to a normal focal-length a little above its widest angle of 28mm. Move close enough so each fills the LCD monitor. You'll discover you are at the correct distance for viewing the prints. With a longer focal-length you would feel too far away, and with a shorter one too close.

7.4 WIDE-ANGLE LENSES

Zooming out gives you a wide-angle of view that lets you capture a wide expanse of a scene. This wide angle of view is ideal for use in tight spaces, such as when photographing landscapes and in small rooms where you can't position the camera a great distance from the subject.



If you don't get too close to your subjects, wide angle zoom is good for indoor portraits where including the setting is important.

A lens zoomed to a wide-angle also has great depth of field. This great depth of field makes short lenses good for street or action photographs. When out to capture quickly unfolding scenes, keep the lens zoomed out to a wide angle so you'll have maximum depth of field when you respond quickly to a photo opportunity.



Zooming out increases depth of field and widens the angle of coverage making it ideal for interior shots. The great depth of field also makes focusing less critical so you can capture those fleeting moments you might otherwise miss.

Short lenses also let you focus very close to your subject, and the effect this can have on the perspective in your images can be dramatic. Objects very close to the camera loom much larger than those farther in the background. This distortion in the apparent size of objects can deliberately give emphasis and when carried to an extreme, give an unrealistic appearance to a scene.

In addition to zooming your lens all of the way out for wide-angle coverage, some cameras have wide-angle lens adapters that widen it even more.



Shooting down on these two girls makes their heads look much larger than they really are since they are much closer to the camera and its wide-angle lens.

7.5 LONG LENSES

A lens zoomed in on a subject acts somewhat like a telescope: It magnifies the image of your subject. This is especially useful when you can't get close to your subject—or don't want to. Zooming in like this is ideal for wildlife, portrait, and candid photography, whenever getting close to a subject might disturb it.

When you zoom in on a subject, depth of field gets shallower so you must focus carefully. Also, zooming in visually compresses space, making objects in the scene appear closer together than they actually are.

The primary drawback of zooming in is that it gives you a smaller maximum aperture. This smaller maximum aperture may require a longer shutter speed and since a long lens magnifies movement, just as it magnifies the subject, you may have to use a tripod instead of hand-holding the camera.



Zooming in makes distant objects appear compressed. Here a long lens has been used to "compress" a street scene at the foot of the Rocky Mountains in Colorado.

For a telephoto view, you can zoom the lens all the way in. For even more magnification, some cameras have optional lens converters that give you even longer focal lengths.



When the lineup of cement trucks (bottom) is shot head-on with a long lens (top) they appear much closer together than they really are. This is actually due to the distance from the subject, not the focal length of the lens, but the effect is easy to get with a long lens.



A long lens makes the sun look larger in relation to foreground objects.

Digital Zoom

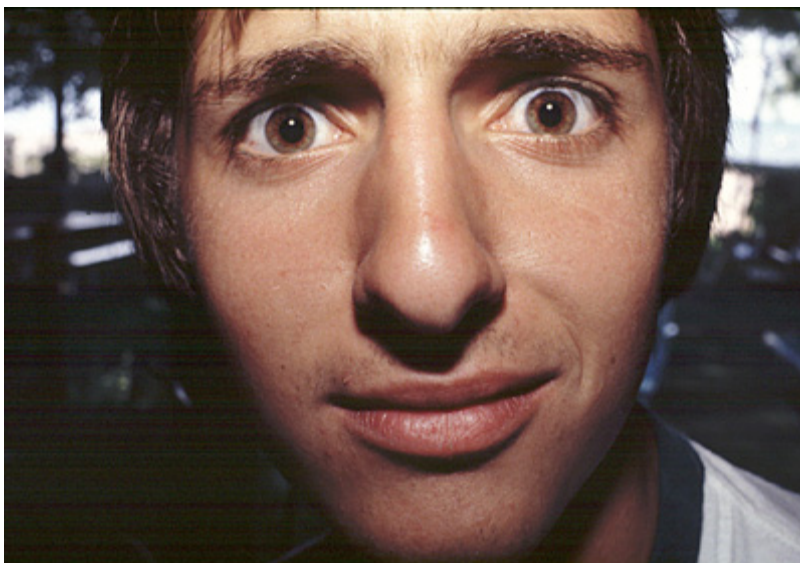
Zoom lenses come in two varieties; optical and digital zooms. An optical zoom lens actually changes the amount of the scene falling on the image sensor. Every pixel in the image contains unique data so the final photo is sharp and clear. A digital zoom lens uses sleight of hand by taking a part of the normal image falling on the sensor and then enlarging it to fill the sensor. It does this by adding new pixels to the image using interpolation. The interpolated image doesn't have as many unique pixels as one taken with an optical zoom so is inferior. In fact, you don't even need this zoom feature because you can get exactly the same effect just by cropping a normal image in a photo-editing program and then enlarging it.

7.6 PORTRAITS WITH A LENS

A zoom lens is an excellent portrait lens, especially for head-and-shoulders portraits. When zoomed in you can keep your distance and still fill the viewfinder frame with the subject. Keeping at a distance eliminates the exaggerated perspective caused by working very close to a subject with a shorter focal length lens. It also helps relax your subjects if they get uneasy, as many people do, when a camera comes close.



A long lens lets you get portraits without crowding in on the subject. This let's you capture more natural expressions.



Using a lens zoomed out to a wide angle and close to the subject adds some distortion to the portrait but it still works as an image. Perhaps not as flattering as it might be, the image is probably more interesting to others than to the subject.

7.7 CONTROLLING PERSPECTIVE

A photograph can appear to compress space so that objects appear closer together than you expect. Another photograph of the same scene can seem to expand space so that objects appear farther apart than normal. These apparent distortions in perspective—the appearance of depth in a photograph—are often attributed to the focal length of the lens being used but are actually caused by the distance of the lens from the subject.



The image on the left appears to be more "open" and spacious than the more visually "compressed" one on the right. However, the image on the right is actually contained in the image on the left. It just appears more compressed because the enlarged section includes only those elements farthest from the camera.



Changing camera-to-subject distance does change perspective as shown here. As the camera is moved closer to the foreground subject (left), the subject appears to increase in size relative to the background. This changing relationship between the size of objects in the foreground and background creates the difference in perspective.

CHAPTER 8, FLASH & LIGHTING



Objectives

- Describe the different kinds of flash available
- Describe how flash illumination falls off with distance
- Explain some points about taking portraits with flash
- Explain when and how you'd use fill flash
- Describe how you'd combine flash with background lighting
- Describe when and how you would use available light instead of flash

Introduction

Automatic electronic flash is so convenient and easy to use that you are usually unaware it even fires. With your camera on automatic, it's always ready when your autoexposure system decides it's needed. But this on-camera flash lighting has certain characteristics that can make a difference in the way your pictures look. For example, the pictures will have a "flat" lighting typical of flash-on-camera shooting. Alternative approaches, such as positioning a separate flash off camera (or using a slave unit) may produce more interesting results. In any event, you will be able to use flash to better advantage as you become more familiar with its characteristics and the various forms available.

Many digital cameras have a variety of flash modes that we'll explore in this chapter. Although they go by different names, these modes typically include Auto that fires the flash whenever the light is too dim to take a photo, Anytime Flash that fires the flash regardless of how much available light there is, Red-eye Reduction that fires a separate lamp to reduce red-eye when taking portraits, Flash Cancel that turns the flash off so you can photograph with available light without the flash firing, and Slow Synchronized that keeps the shutter open longer than usual to lighten the background.

8.1 TYPES OF FLASH

Flash photography has come a long way since the 19th century when a photographer had to ignite a tray filled with gunpowder to illuminate a scene. Almost every digital camera comes with a small built-in automatic flash that is tied into the autoexposure system. These flash units are convenient, however their range is very short; normally around 10 feet or so. They are also so close to the lens, photos of people often capture them with red eyes. They emit a hard, direct light and can't be rotated to bounce flash off a wall or ceiling to soften it.



Flash on camera is convenient to use: every place you and your camera go, the flash goes with you. All flash-on-camera photos look very much the same—a flat, relatively shadowless light that minimizes surface textures and volumes.

To overcome these limitations, a variety of external flash units are made. These units work like those on 35mm SLR's. They either slip into a "hot shoe" on the digital camera that both holds them and connects them to the camera shutter release and autoexposure system, or they are mounted on brackets and connected to the camera by a synch cord, basically a small cable. This synch (pronounced "sink") cord makes the same electrical connection that the hot shoe does but lets you position the flash off camera.

Another way to use external flash is to buy a slave flash unit that fires automatically when it senses the burst of flash from the camera's built-in flash unit. Since many digital cameras fire the flash twice for each picture (the first is a preflash to set color balance), these units have to be adjustable so they fire when the camera's second flash goes off. These units are more powerful than the on-camera flash and also allow you to rotate the head to use bounce flash to soften shadows.



A slave flash unit. Courtesy of [Digi-Slave](#).

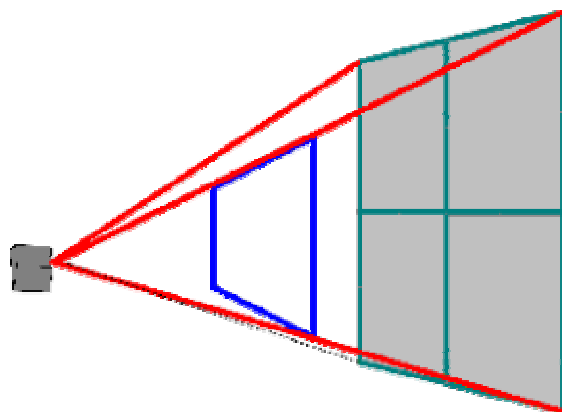
8.2 HOW FLASH WORKS

Every flash has a maximum useful range. How bright the light from a flash is when it reaches a subject depends on the flash's power and on how far the light has to travel. The further the subject is from the flash, the less light will reach it and so the less light will be reflected from the subject back toward the camera.



Flash light falls off (becomes dimmer) the farther it travels. Objects near the flash will be lighter in a picture than objects farther away. You can use this to advantage; for example, at night you can isolate a subject against a dark background.

When the flash fires, the beam of light expands as it moves farther from the camera. As a result, subjects nearer the flash will be illuminated with a more intense light than subjects farther away. The rate at which the light falls off is described by the inverse square law. If the distance between the flash and subject is doubled, only one quarter the amount of light will reach the subject because the same amount of light is spread over a larger area. Conversely, when the distance is halved, four times as much light falls on a given area.



The inverse square law describes the relationship between a subject's distance and how much light will fall upon it from the flash. If the distance is doubled, only one quarter the amount of light will reach the subject. This is because the light emitted by the flash expands as it moves farther from the camera. The same amount of light is spread over a larger area. Less light therefore falls on a subject of fixed size as the subject moves farther from the flash. Conversely, when the distance is halved, four times as much light falls on a given area.

— 5 feet —+— 10 feet —

When subjects in an image are located at different distances from the camera, the exposure will only be correct for those at one distance—normally those closest to the camera or in the middle of the area metered by the autoexposure system. Subjects located farther from the flash will be increasingly darker the farther they are from the flash.

8.3 PORTRAITS WITH FLASH

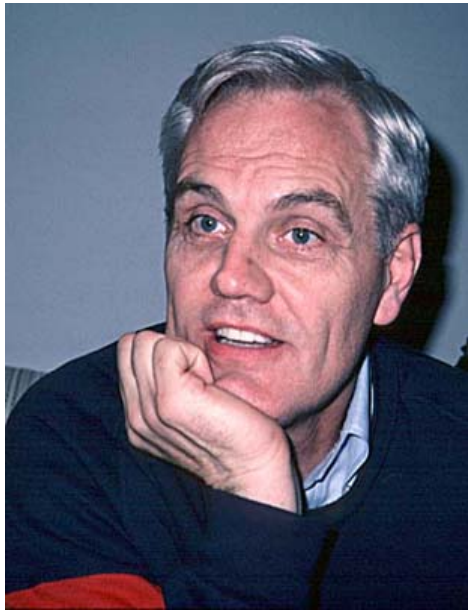
Flash is a good source of light when you want to make portraits, particularly of children. The light from the flash is so fast that you never have to worry about your subject moving during the exposure and blurring the picture. For the same reason you don't have to be quite as careful about camera motion blurring the image; you can hand-hold the camera and shoot as rapidly as the flash will recharge.

Positioning the Flash and Subjects

You may want to choose carefully the position of the flash. Light from a flash built-into the camera often produces less attractive results than if you bounce the light onto the subject off a wall, ceiling, or umbrella reflector.



When photographing more than one subject, each is given the same importance when lined up parallel to the camera because each receives the same amount of flash illumination. If they are at different distances from the flash, they will be illuminated differently. This is a good way to make one more visually dominant than others in the image.



When a subject is placed close to a wall, there will almost always be a distracting shadow in the image cast by the light from the flash. By moving the subject away from a wall, these shadows disappear.

Red-eye

When photographing people, you'll often see images with what's called "red eye." The light from a flash has entered through the subject's pupil and reflected off the back of the eye (the retina) and back out to the camera. Since the retina is full of thin blood vessels, it takes on a red color. To eliminate red-eye, many cameras have a "red-eye reduction" mode. This mode works by firing a short pre-flash lamp or a burst of flashes to close the subject's iris a moment before the actual flash fires to take the picture.

To minimize red eye, you can also move an external flash farther away from the axis of the camera lens, tell the subject not to look directly at the camera, or increase the overall room lighting. You can also remove red-eye later using software included with the camera, but it's easier to avoid it to begin with.



Here a champion figure skater displays the classic "red eyes."

8.4 USING FILL FLASH

When photographing people or other subjects in bright sun, shadow areas can be so dark in the image that they show little or no detail. If the shadow covers a large part of the subject, the effect can be distracting and unattractive. You can lighten such shadows by using flash to "fill" the shadows to lighten them. In this mode the flash fires even when there is enough available light to take the picture.



With no fill flash the bright background has underexposed the main subjects.



Using fill flash, the people now stand out from the background.



Fill flash eliminates dark shadows in a backlit shot. Photo courtesy of Cathy Morin.

8.5 USING SLOW SYNC

Often, pictures taken with flash show a well exposed foreground subject against a black or dark background. The slow synchronized mode is designed to minimize this problem by leaving the shutter open longer than usual to lighten the background.

In many cases, the slow shutter speed used in this mode allows blur from rapidly moving objects or camera shake to appear as blur in the images. To avoid blur, use a tripod and photograph static subjects. Or, use this effect creatively. A short flash burst combined with a long shutter speed gives interesting effects. The flash freezes objects sharply, and then the dim ambient light blurs the image slightly and moving lights appear as streaks.



A slow shutter speed and flash combined to create this photo showing both sharpness and blur.

TIP

When the flash is set to slow sync, long exposure times may create unwanted blur in the image. At times like this, you may want to use a camera support (see Topic 0.0.)

8.6 USING AVAILABLE LIGHT

There are times when the light is dim but you want to capture the unique colors of the available light. In these circumstances you need to turn the flash off and support the camera for a long exposure. If you don't turn off the flash it will fire and the foreground subjects will appear as if photographed in daylight. If you don't support the camera you will likely have blur from camera movement.



Available light can add beautiful colors to a photograph.

Flash Off

When the flash is off, long exposure times may create blur in the image. At times like this, you may want to use a camera support. (See Topic 0.0.)

When photographing in dim light there are things you can do to get better results when not using flash. Try the following as described in Topic 0.0:

- Increase the camera's sensitivity.
- Use the camera's selftimer or remote control.
- Support the camera or use a tripod.

CHAPTER 9, EDITING IMAGES



Introduction

In a traditional darkroom, you control images with choices of films, chemicals, papers and processes. In the digital equivalent of the darkroom, you do so with a computer system and a photo editing program. Just as in a traditional darkroom, the quality of your digital tools has an impact on the quality of your images.

Digital images can be edited in a wide variety of ways using photo editing software. In some cases an editing program is used to "improve" an image by eliminating or reducing its flaws. In other cases it is used to take an image to a new place, making it something it never was.

9.1 THE DIGITAL DARKROOM

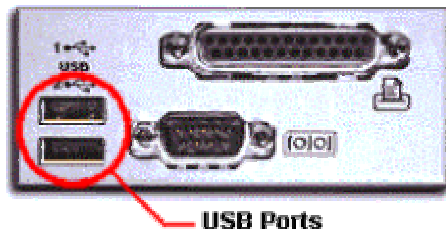
Digital photography has two distinct phases: image capture and everything else. In this topic we cover some of the things you need (or might want) for that second phase: image editing, printing, storage, and sharing. In traditional photography, this is called the darkroom phase and that term has been adopted in digital photography. Although the term "digital darkroom" has a nice ring to it, it's not at all accurate. Most of what digital photographers do, we do with the lights on. However, no other collective term has yet become popular for all of the activities that are performed on digital images after they are captured. In this topic, we take a look at the things you should seriously consider having in your digital darkroom. They are not all essential to getting the job done, but they are essential to getting it done as easily and quickly as possible.

The Computer

The ideal computer is fast, has a 21" display, weighs only a few pounds, fits in your pocket, has both USB and Firewire connections, and has a cable or DSL modem. Of course no such animal exists so you have to make compromises, get a notebook with a docking station, or have more than one computer.

Desktop Computers

The only reason to give over half your desk to a computer is because these units are cheap and very expandable. My system has a 21" monitor that looms over me because I'd have to push its backend out a window to get more room between it and I. However, it has a 22 Gigabyte drive and a 500 MHz processor, all for under \$2K (the monitor was passed down from the previous system).



Be sure your new computer has these ports. USB is the wave of the future because you can plug in devices such as card readers and cameras without special software or even turning off the computer. The only thing better is Firewire, which isn't yet in widespread use.

Notebook Computers

Notebook computers are expensive compared to big desktop units and this keeps a lot of people like me from buying one. However, if you have the cash to spend, or even better, work for a company that gives you one, they are ideal for desktop photography. Relatively large drives and large screens makes it easy to store, edit, and even distribute images. There's a slew of them to choose from and new models are introduced all the time so I won't make recommendations. Just be sure you get a large enough hard drive to store images when you're on the road. Also, you might look for one that has a docking station. These allow you to use a full-size screen and keyboard when you're home and also provide additional slots for expansion.



You can tell when Steve Jobs has hung his hat by the design of the computers coming out the loading dock door. he's about the only one in computing that thinks the "look" of a computer is worth a hoot. Courtesy of Apple.

If a notebook has a PC Card slot, all you need to read CompactFlash or SmartMedia cards is an adapter.



An adapter lets you use CompactFlash and SmartMedia cards in a PC Card slot. Courtesy of Lexar Media.

Mini-Notebook Computers

Everyone has their own needs and preferences. However, if I had the bucks to spend, there would be a mini-notebook in my camera bag right now. These very small computers are great to take with you so you have a place to view, store, and distribute photos.



The Toshiba Libretto is a tiny Windows computer measuring only 8.27"L x 5.19"W x 1.38"H. It has two PC Card slots into which you can plug other devices such as printers or CD-R drives. Courtesy of Toshiba.

Storage Devices

There used to be a saying to the effect that IBM built larger and faster computers only to run bigger and slower software. There's no question that the personal computer market has gone the same way. Files have gotten so large that the venerable old floppy disk has long since lost almost any real usefulness (apologies to Mavica owners). Yet, like our appendix for which there is no known use, these drives are built into almost every machine made. There are a variety of new formats vying for dominance but so far, the Zip drive from Iomega is far ahead in the race. It doesn't matter which 'superdisk' format you choose, unless you want to exchange

disks or use them on different computers. The various competing disks can't be read using other formats' drives.



Iomega makes a Zip drive that plugs into the USB port. It's fast and perfect for moving from system to system. Just plug and play.

Zip drives are nice, but the Zip disks are expensive. When you hand one to a friend, you always hope you'll get it back. If you're like me and like to toss disks around like Frisbees, you really need a CD-R drive. I never realized how great these are until I got one on my new system. I can just drag and drop hundreds of image files onto a 600+ Megabyte CD disc and give it to a friend. It's theirs forever. I bought 100 or so discs at 20-cents each (after a rebate that has yet to arrive). Even without a big sale, you can find them for under \$2. You can find these drives on places such as [PriceScan](#) for under \$200. There are also CD-RW discs that you can write on and erase just like regular disks. The discs are more than twice as expensive as CD-R discs, so you might not want to spend the bucks.



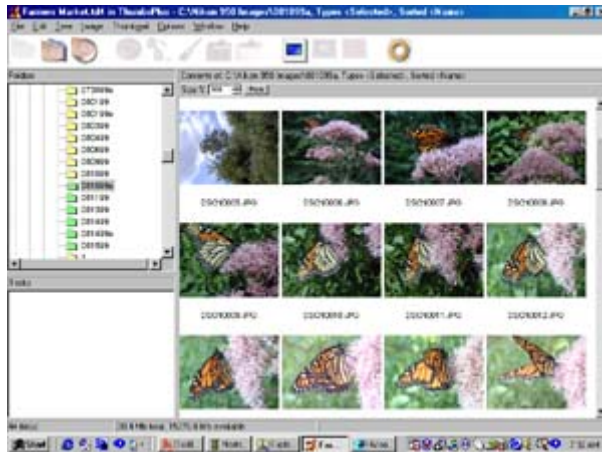
You can only write on CD-R disks once, but that's really an advantage. You'll never overwrite your original file after making changes to it.

Software

Most digital cameras come with software that lets you download your images to a computer. Once there, you have two big needs: organizing them and editing them. Lets take a look at the two software packages that are most widely used by digital photographers.

Organizing Images

Once you have a lot of images, the problem becomes one of locating the one you want. This is the role of an image management program. There's an [entire section on this site devoted to this topic](#), but you can't go wrong trying out ThumbsPlus.



ThumbsPlus is a shareware program that has found very wide acceptance. There's even a Mac version in beta.

Editing Images

Once you have found the image you want to work with, you may need to edit it. Photographers usually do only a few things such as adjust curves, color balance, contrast, and brightness or change an image's size so it can be posted on the Web or sent by e-mail. We can also use filters to change the look of a photograph into some other art form. There are lots of programs that perform these tasks very well, [Paint Shop Pro](#) being one of the most widely used (it's shareware, so you can try it for free). However, the standard by which the others are judged is Photoshop, a program that does what you'll probably want to do and ten thousand other things as well. If the program has a problem, it's that it'll take you months to discover you don't need 99% or what it offers unless you're making a living at printing photographs in magazines or working at a very very high level.



Photoshop is the standard by which all other image editing program are judged.

Scanners

People who use digital cameras, rarely have use for a scanner because their images are already in digital form. However, for those of us who work in traditional photography as well as digital, we often find ourselves having to scan slides, negatives, or prints. To do so we need slide or flatbed scanners.



Slide scanners, such as this Nikon Coolscan, are used to scan slides or negatives into digital form. Courtesy of Nikon.



Flatbed scanners are used to scan prints and other flat objects. Courtesy of UMAX.

Odds and Ends

In addition to the big things, you can always find a number of other things that make digital photography faster, easier, or more fun.

- **WinZip or Stuffit** are good for compressing files and gathering a group of files together into a single file for sending by email. Although no advantage is gained in compressing most images from a digital camera, being able to store a number together in the same file can be very useful. The only drawback is that the recipient needs the same software to extract the images.
- **FTP programs**, such as CuteFTP, are used to upload images and other files to a Web site.
- **Web Sites** are nice if you want to show off your work. There are a number of services that offer free space
- **Cable or DSL connections** are much faster and better than modem connections. For one thing, they are always on so you don't need to dial up. For another they download files maybe 50 or so times faster than the fastest modem.

9.2 THE MONITOR

Larger displays from recognized manufacturers will give you better results, because they allow you to better see on the screen what you'll get in a printout. They also support a wider range of resolutions.



This Apple ColorSync Display provides a 20-inch screen (19.02-inch diagonal viewable image size). It's the ideal choice for anyone whose work demands resolution flexibility, color accuracy, and a full two-page display for detailed documents. Courtesy of [Apple](#).

Dot Pitch

All CRT displays use an electron beam that scans the screen which is covered with dots of colored phosphor. Between the electron gun and the screen is a mask that allows the sweeping beam to strike the screen only in selected areas (pixels). There are two kinds of masks; shadow masks and slot masks.

- A **shadow mask** is a screen drilled with holes. The closer these holes are together in this screen, the higher the screen's resolution.
- A **slot mask** (or aperture grill), like those in Sony Trinitron tubes, uses slots cut in the plate instead of round holes.

The spacing between the center of one dot or slot of the same color is called the **dot pitch** and is given in millimeters. The closer these are together, the better the screen's display (all other things being equal). The images are crisper and edges and lines look smoother. To compare monitors with the different types of masks, you need to know that the numbers are not equivalent. For example, a monitor using a shadow mask and having a dot pitch of .27mm is about the same as a .25 mm dot pitch on a monitor using a slot mask. You can determine a monitor's maximum resolution by dividing its width by its dot pitch. For example, a 14", .28mm dot pitch monitor measuring 300mm across could clearly display 1071 dots.

Dot pitch isn't a reliable measure of monitor quality because it's often distorted by different measurement techniques. Some monitors, such as the Sony Trinitron, use stripes instead of dots so there is no comparable measurement.

Resolution

On any given monitor, changing screen resolutions changes the size of displayed objects such as icons, text, buttons, and images. As the resolution increases, object sizes decrease but they do appear sharper. Take a look here at the same image displayed at three different resolutions: 640 x 480, 600 x 800, and 1024 x 768.



640 x 480. At this resolution, Photoshop fills the screen.



800 x 600. When the screen resolution is increased, Photoshop gets smaller.



1024 x 768. When the resolution is increased again, Photoshop gets even smaller.

Because higher resolutions make things smaller on the screen, not all screen resolutions on a given sized screen make for comfortable viewing. For example, a screen resolution of 1024 x 768 on a 14" monitor makes text too small to be easily read. On the other hand, using a resolution of 640 x 480 on a 21" monitor makes things unreasonably large for those with normal vision (but like a large-print edition for folks with vision problems). Here is a table that you can use as a guideline when selecting a monitor or changing the resolution of the one you have.

Resolution	Monitor Size				
	14	15	17	20	21
640 x 480	X				
800 x 600	X	X			
1024 x 768		X	X	X	
1280 x 1024				X	X
1600 x 1200					X

White Point

Light sources have different color temperatures. When you set up your monitor, you can adjust its "white point" which is another name for its color temperature. The monitor's white point has a big effect on how the image looks on the screen. It's best to match it to the way you'll finally output the image so you can preview the end results better. If your images will be displayed on a monitor set it to 9300K, and if they are to be displayed on a TV set it to 6500. If they are to be printed, set it to 5000.

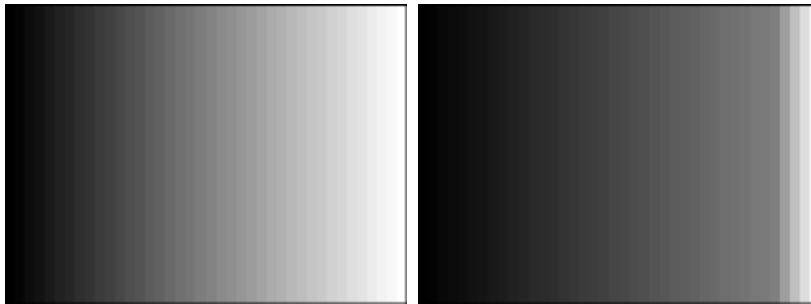
Source Color	Temperature
Computer monitor	9300K (adjustable)
Average daylight	6500K
Television monitor	6500K
Cool white fluorescent	4300K
Tungsten lamp	2800K

Sunlight at sunset

2000K

Gamma Correction

The image sensor in a digital camera is a linear device—the output signal is directly proportional to the scene illumination and exposure—doubling the exposure doubles the output signal. However, the phosphors that are used to make display monitors are non-linear. Typically, the phosphors have less gain for dark signals and more gain for bright signals. As the input voltage is increased, the screen brightness doesn't change smoothly because it's affected by electrostatic effects in the electron gun. This means that if you input a linear signal, the display on the screen is nonlinear and images tend to be darker with detail lost in the shadow areas. To compensate for this, the monitor adjusts the input signal to boost the dark areas and reduce the light ones. This ensures that combination of camera and monitor working together produce a linear effect. This process of adjusting the incoming signal is called **Gamma correction**. The term Gamma comes from the fact that the screen's brightness is proportional to the input voltage raised to the power 2.5, or **gamma**.



Input Image

Uncorrected output image

To make the displayed image better match the original image, the input signal can be adjusted to distort the signal in the opposite direction from the distortions of the CRT. For example, if the original image has a middle gray tone, the correction lightens it. When it's then displayed on the screen, the CRT darkens it again, bringing it back to middle gray. This adjustment is called **gamma correction**. Gamma correction controls the overall brightness of an image and images that haven't been properly corrected will look too light or too dark. Varying gamma also affects colors by changing the ratios of red, green, and blue. For this reason, you need to correct it to accurately reproduce colors.

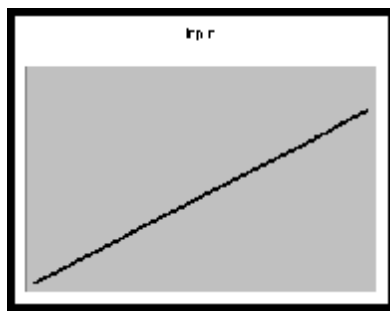
Most monitors have a gamma of about 2.5. In the art below you'll see that a CRT with a gamma of 2.5 has a response like the one shown in the top two charts. In the bottom three charts you see what happens to the output signal when the input signal is first corrected.

Although gamma correction sounds technical, it's important if you want images displayed accurately on your screen or if you want to post images on the Web and have them displayed correctly on other people's screens.

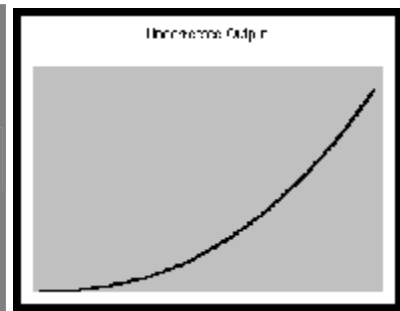
Input

Gamma Correction

Output



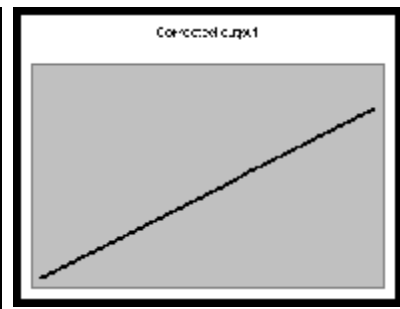
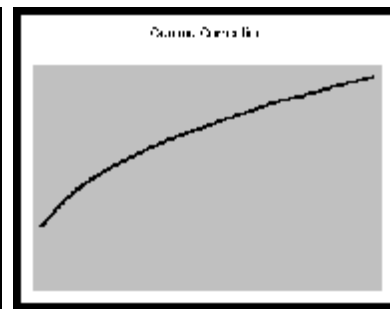
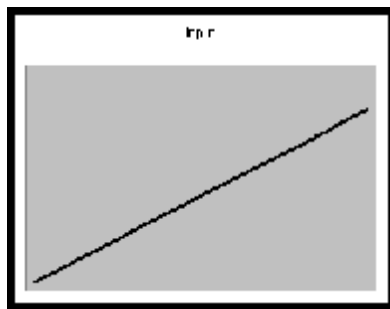
None



1. The input curve is straight and linear.

2. No gamma correction is used.

3. The output curve is distorted.



1. The input curve is straight and linear.

2. Gamma correction adjusts the input in such a way that it compensates for the distortion.

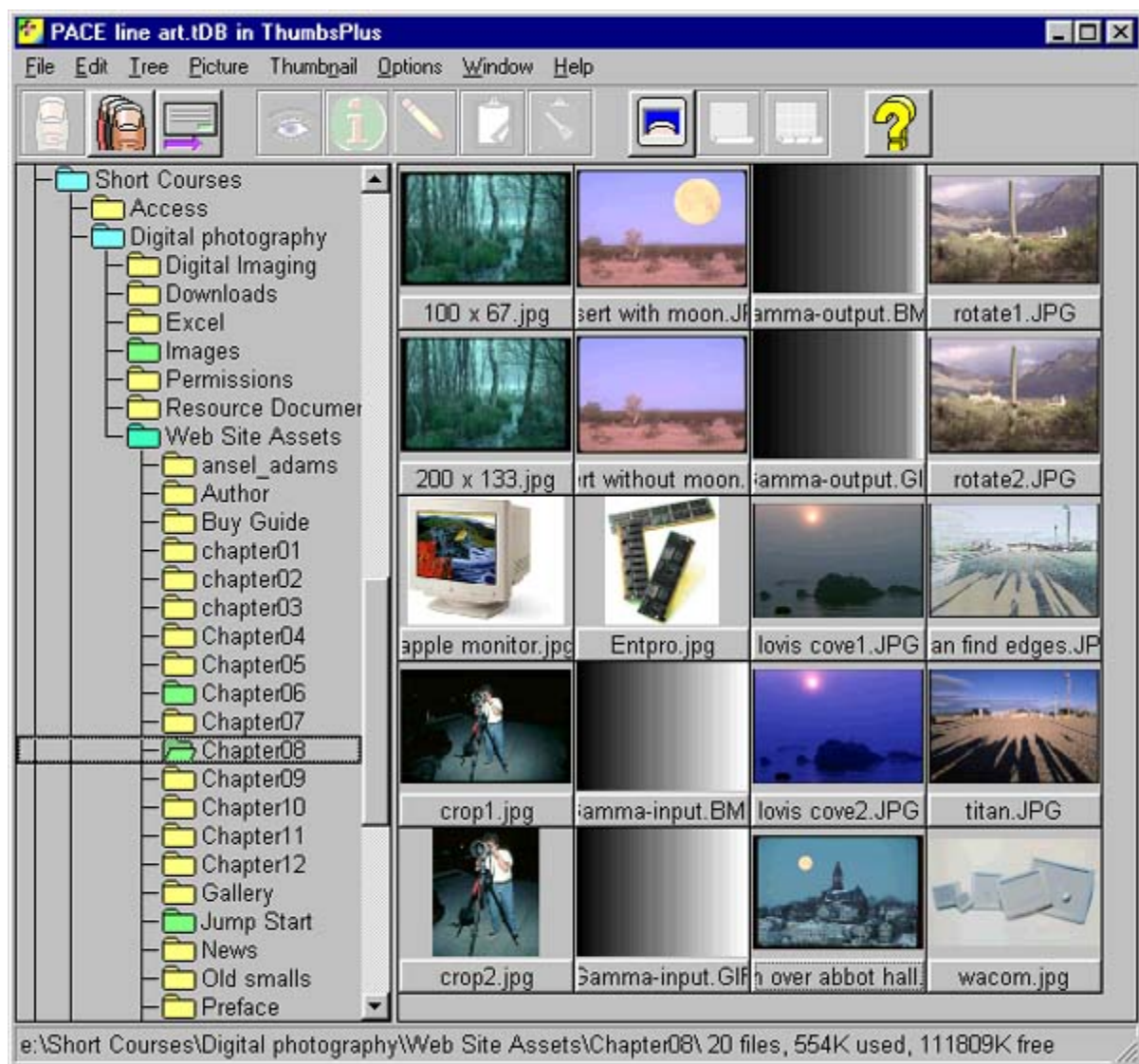
3. The output curve is straight and linear.

9.3 IMAGE MANAGEMENT

It doesn't take long to be overrun with images; and all of them with meaningless names to boot. In this topic we explore some of the software tools designed to help you find, identify, organize, and use the images you have take. There is a spectrum of image management software ranging from programs that just transfer images from the camera to the computer to those that manage huge collections of images. Here are just some of the things these programs can do:

- Acquire images from the camera
- View the images on the system
- Catalog the images, usually using thumbnails
- Edit the images
- Post thumbnails of the images on the Web

It pays to look at these programs because it sometimes seems like the software that comes with your camera was written by Martians. The programmers frequently ignore the most common Windows or Macintosh assumptions so the programs look and act strange to many users. In addition, they crash or hang systems all too often. A number of third-party products have been developed to fill the vacuum created by these half-hearted efforts on the part of the camera manufacturers. Here are some of those, and much, much, more.

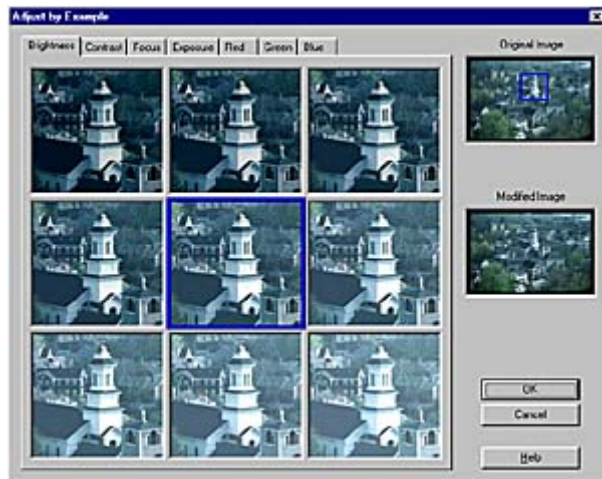


The ThumbsPlus screen display.

There are a lot of programs in this area so I asked Larry Reeve at PolyBytes how someone should go about selecting a program in this area. He responded "How to select between good products? That is a good question. Most people just download a bunch and drive them a while. I think PolyView is very strong in usability, printing capabilities, and format manipulations. Many of the ones in your list are also very good, however, so it is a very tough call. My focus lately has been on collection management and printing. Those would seem to be features that are very useful to digital photographers." I like his honesty and if you're going to try one of these out, you might start with his.

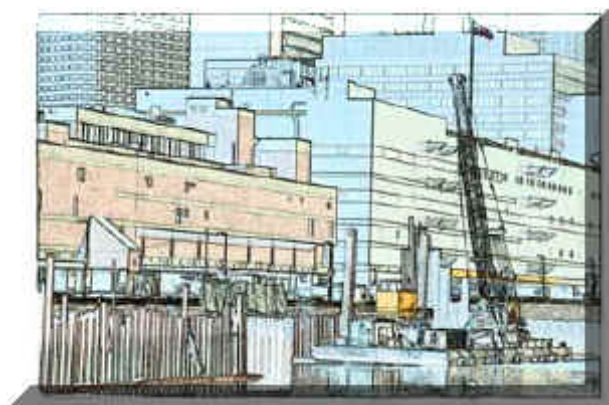
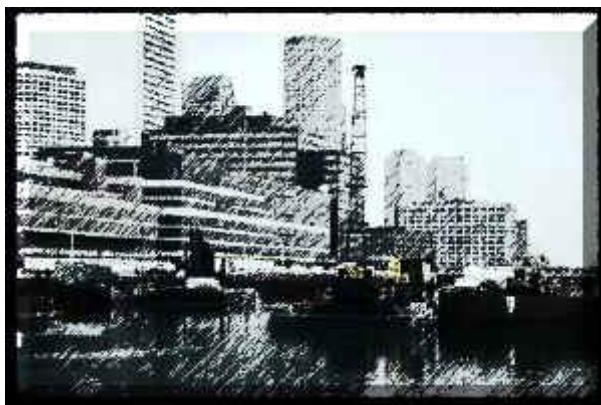
9.4 PHOTO-EDITING SOFTWARE

Photo editing software ranges from easy to use, one-click corrections, to the powerful and complicated Photoshop. Where you want to place yourself along this spectrum depends a lot on how serious you are and what you want to accomplish. For example, if all you want to do is prepare images to post on the Web, a shareware program such as Paint Shop Pro will more than suffice. However, if you plan on having your images printed on a color press or included in a professional produced publication, the Photoshop is the way to go.



Some programs such as G&A Imaging's [PhotoRecall](#) are easy to use because they show you a spectrum of changes and let you pick the one you like best. Here are nine images with different levels of brightness to choose from.

Since one of the most interesting things to do with digital images is to manipulate them, be sure to look into filters. Many of these like the unsharp filter are used to make your images look more like the original scene. But many others can make photos look like paintings, stained glass windows, or hundreds of other objects. They can emboss images, add textures, twist and twirl them, and create all kinds of creative havoc. They are easy to use, you just select the command and sit back and watch your computer go to work. If you don't like the result, just click the undo command and try another filter. 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. Many photo editing programs come with filters built-in, but some programs allow you to purchase separate plug-ins to expand your library of effects from which to choose.



9.5 GRAPHIC FILE FORMATS

Digital photographs are stored as bitmaps—a series of individually addressable pixels. Over the years, a number of different bitmap image formats have been developed. Each has its own unique characteristics which determine when and where you might choose it over the others. However, whatever format you choose, there are programs that will convert it to any of the other formats.

Bit-mapped vs Vector Images

All of the still images that you see on the Web, or in multimedia programs, and many that you see in print, have been created or manipulated on a computer in a digital format. There are two basic forms of computer graphics: bit-maps and vector graphics. The kind you use determines the tools you choose. Bitmap formats are the ones used for digital photographs. Vector formats are used only for line drawings.

Bit-mapped images

Bit-map images are formed from pixels—a matrix of dots with different colors. Bitmap images are defined by their dimension in pixels as well as by the number of colors they represent. For example, a 640X480 image contains 640 pixels and 480 pixels in horizontal and vertical direction respectively. If you enlarge a small area of a bit-mapped image, you can clearly see the pixels that are used to create it. When viewed normally, the small pixels merge into continuous tones much as the dots used to create newspaper photographs do. Each of the small pixels can be a shade of gray or a color. Using 24-bit color, each pixel can be set to any one of 16 million colors. All digital photographs and paintings are bitmapped, and any other kind of image can be saved or exported into a bitmap format. In fact, when you print any kind of image on a laser or ink-jet printer, it is first converted (**rasterized**) by either the computer or printer into a bitmap form so it can be printed with the dots the printer uses. To edit or modify these bitmapped images you use a paint program. Bitmap images are widely used but they suffer from a few unavoidable problems. They must be printed or displayed at a size determined by the number of pixels in the image. Printing or displaying one at any other size can create unwanted patterns in the image. Bitmap images also have large file sizes that are determined by the image's dimensions in pixels and its color depth. To reduce this problem, some graphic formats such as GIF and JPEG are used to store images in compressed format.

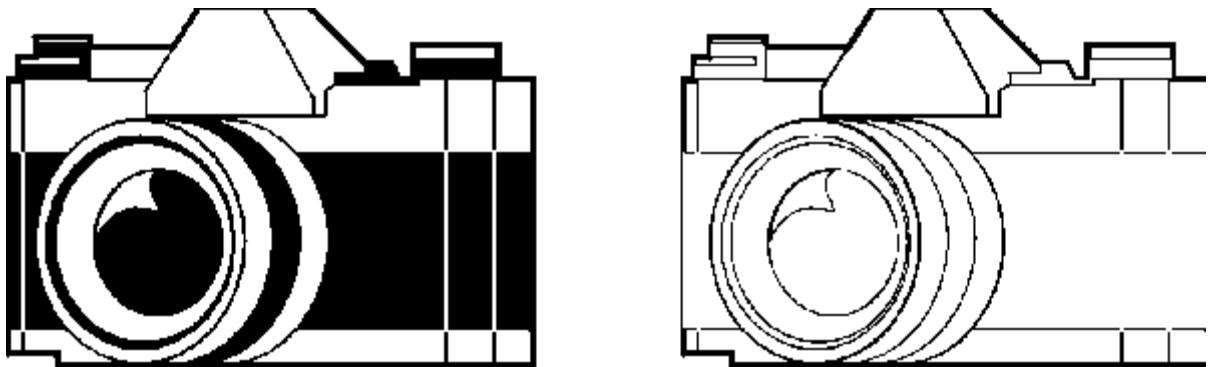
Vector graphics

Vector graphics are really just a list of graphical objects such as lines, rectangles, ellipses, arcs, or curves—called **primitives**. **Draw programs**, also called **vector graphics programs**, are used to create and edit these vector graphics. These programs store the primitives as a set of numerical coordinates and mathematical formulas that specify their shape and position in the image. This format is widely used by computer-aided design programs to create detailed engineering and design drawings. It has also become popular in multimedia when 3D animation is desired. Draw programs have a number of advantages over paint-type programs. These include:

- Precise control over lines and colors.

- Ability to skew and rotate objects to see them from different angles or add perspective.
- Ability to scale objects to any size to fit the available space. Vector graphics always print at the best resolution of the printer you use, no matter what size you make them.
- Color blends and shadings can be easily changed.
- Text can be wrapped around objects.

When working with a draw program, you can display the image in two views: wire frame view or shaded. In wire frame view, you see just the underlying lines—a skeletal view of the image. The image is displayed this way because it can be manipulated on the screen a lot faster. To see what the finished model looks like, you can apply colors to the wire frame and display it with the wire frame covered by these shaded surfaces.



The camera is shown in shaded view (left) and wireframe view (right). The ability to shift between these two views is characteristic of vector (draw) programs.

Native and Transfer Image Formats

Since bit-mapped images are the ones that most concern photographers, those are the ones we'll concentrate on in this section. Bitmap file formats fall into two subclasses; native and transfer or exchange formats.

Native Formats

As new programs are introduced, developers have a tendency to create proprietary, or **native formats** that can be read only by their programs. Part of this desire is to have a competitive advantage. But there is also a need sometimes to design a new format to accommodate new procedures or possibilities. However, native formats present serious problems for users who want to transfer image files among programs and share them with others. They are often not readable by other programs.

Transfer Formats

Because native formats are so limiting, **transfer formats** have been designed to allow images to be moved between application programs and even between operating systems. Some of these formats started out as native formats but were so widely adopted by others that they became transfer formats. Almost all graphics applications can open and save these transfer formats as well as their own native formats.

Popular Image Formats

Over the years, hundreds of image file formats have been created. However, most of these have fallen into disuse or are encountered only in special circumstances. As new demands arise, such as displaying images on the Web, new formats emerge. Some, such as Photo CD, gain wide acceptance. Others generate a lot of excitement and then disappear because they are found to have flaws. In this section we explore those formats you are most likely to use or encounter.

TIFF (.TIF)

TIFF (Tag Image File Format), pronounced "tiff," was originally developed by Aldus Corporation to save images created by scanners, frame grabbers, and photo editing programs. This format has been widely accepted and widely supported as an image transfer format not tied to specific scanners, printers, or computer display hardware. TIFF is also a popular format for desktop publishing applications. There are several variations of the format, called **extensions**, so you may have occasional problems opening one from another source. Some versions are compressed using the LZW or other lossless methods. TIFF files support up to 24-bit colors.

PICT (.PIC)

The **PICT** format, pronounced "pick," was introduced along with MacDraw software for the Macintosh. It has since become a Macintosh standard.

EPS (.EPS)

EPS (Encapsulated PostScript) files, pronounced a letter at a time "E-P-S," use a format developed by Adobe for PostScript printers. These files generally have two parts. The first is a text description that tells a PostScript printer how to output the image. The second is an optionally bit-mapped PICT image for on-screen previews. Once an image has been saved in the EPS format, you can import it into other programs and scale and crop it. However, its contents are often no longer editable except by a few programs such as Adobe Illustrator. For this reason, these files are generally created at the end of the process when they are about to be incorporated into a printed publication.

BMP (.BMP)

BMP, pronounced a letter at a time "B-M-P," files use a Windows bitmap format. These images are stored in a device-independent bitmap (DIB) format that allows Windows to display the bitmap on any type of display device. The term "device independent" means that the bitmap specifies pixel color in a form independent of the method used by a display to represent color. The default filename extension is .BMP and these files come in two formats:

- The OS/2 format is not compressed (RGB encoded). RGB encoding supports 24-bit colors.
- Windows BMP and DIB files may be saved using no compression (RGB encoded), or using **run length encoded** lossless compression (RLE encoded). RLE supports only 256 colors.

Windows can store color data along with the image it affects. When stored like this, the image is called a Microsoft **Device Independent Bitmap**, or DIB. When written out to a file, it is in the Microsoft Bitmap Format, or BMP. References to the DIB file format actually refer to BMP.

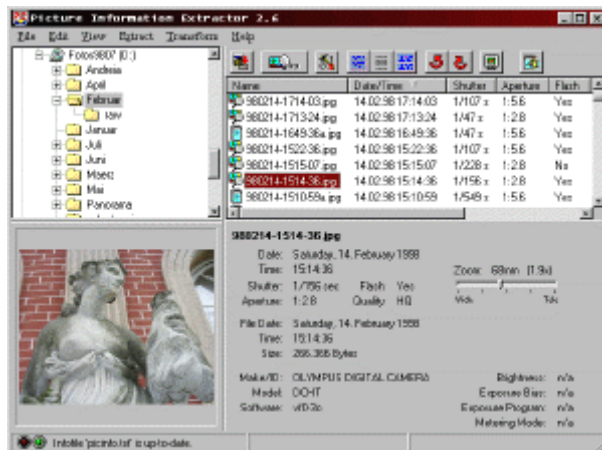
Windows RLE files are Windows DIB files that use RLE compression. Using RLE compressions to save an image as a DIB or BMP, produces an RLE file. The only difference is the filename extension.

JPEG (.JPG)

The **JPEG** (Joint Photographic Experts Group) format, pronounced "jay-peg," is by far the most popular format for display of photographic images on the Web. The term "JPEG" is often used to describe the JFIF file format (JPEG File Interchange Format). JFIF is the actual file format that contains an image compressed with the JPEG method. These newer JFIF files originally used the JPG extension, however, the latest standard calls for using a JIF extension instead. The format is optimized for the display of photographs and doesn't work as well as GIF for type or line drawings (GIF is optimized for those). JPEG images have two distinctive features:

- JPEG uses a lossy compression scheme but you can vary the amount of compression and hence trade off file size for image quality, even making extremely small files with poor quality.
- JPEG supports 24-bit color. GIF, the other format widely used on the Web supports only 8-bits.

Compression is performed on blocks of pixels eight on a side. You can see these blocks when you use the highest levels of compression or greatly enlarge the image. JPEG is a two pass compression and de-compression algorithm. This means it takes longer to load and display than a gif file. You can save images in a progressive JPEG format that works somewhat like an interlaced GIF. While a standard JPEG loads from top to bottom, a progressive JPEG displays the entire image starting with the largest blocks. This allows the image to be displayed first in low-resolution and then filled in as more data arrives. When you save an image in this format, you can specify the number of progressive scans. Don't use JPEG to save original images you expect to modify later. 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, the image becomes more and more degraded. Be sure to save your originals in a loss-free format such as TIFF or BMP at maximum color depth. Also, when you save an image as a JPEG, the image on the screen won't reflect the compression unless you load the saved version.



When you take a photo with a digital camera, exposure information such as shutter speed and aperture is saved in a header to the image file. PIE is a file utility that extracts the camera information from the raw .jpg and renames the PIC000XX.JPG filename to a more computer friendly name keyed to the date and time as well as other photo information. There are basically two standards for picture information headers: Olympus/Sanyo/Casio-compatible and EXIF standard. Most of the new cameras are EXIF-compatible, but there are still camera specific information such as zoom values or quality modes. Courtesy of [juworld](http://juworld.com).

PNG (.PNG)

PNG (Portable Network Graphics), pronounced "ping," has been developed to replace the aging GIF format and it is supported by both Microsoft Internet Explorer and Netscape Navigator. PNG, like GIF is a lossless format, but it has some features that the GIF format doesn't. These include 254 levels of transparency (GIF supports only one), more control over image brightness, and support for more than 48 bits per pixel. (GIF supports 8 for 256 colors). PNG also supports progressive rendering, as interlaced GIFs do, and tends to compress better than a GIF.

GIFs (.GIF)

GIF (Graphics Interchange Format) format images, pronounced "jiff," are widely used on the Web but mostly for line art, not for photographic images. This format stores up to 256 colors from an image in a table called a **palette**. Since images have millions of colors, a program such as PhotoShop selects the best ones to represent the whole when you save the image in this format. When displayed, each pixel in the image is then displayed as one of the colors from the table, much like painting by numbers.

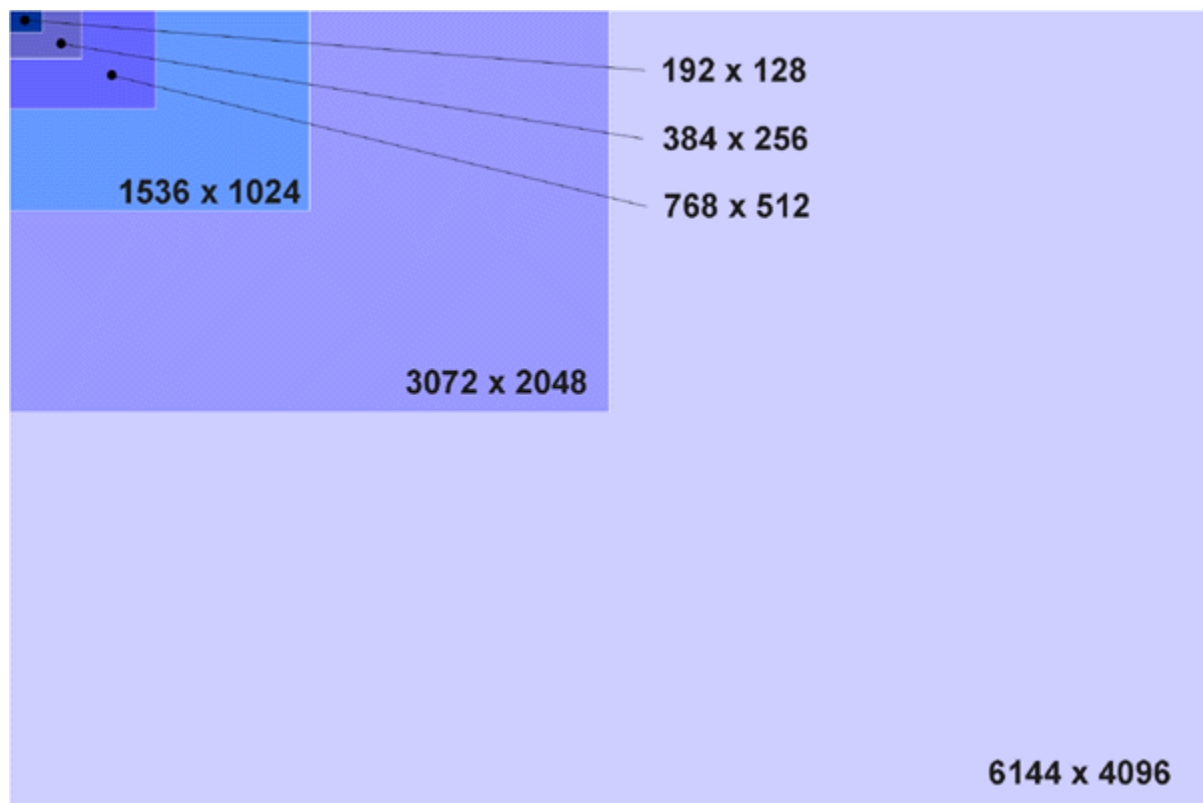
There are two versions of GIF in use on the Web; the original GIF 87a and a newer GIF 89a. Both versions can use interlacing; storing images using four passes instead of one. Normally, when an image is displayed in a browser, it is transmitted a row at a time starting at the top row and filling in down the page. When saved as an interlaced GIF, it is first sent at its full size but with a very low resolution. This allows a person to get some idea of all of the contents of the image file before it is completely transmitted. As more pixels are sent in the next three passes the image fills in and eventually reaches its full resolution. The newer GIF 89a version adds some additional capabilities that include the following:

- Image backgrounds can be made **transparent**. To do so, you specify which color in the table is to be transparent. When viewed with a Web browser, the browser replaces every pixel in the image that is this color with a pixel from the web page's background. This allows the background to show through the image in those areas. You have to choose the transparent color carefully. If you select one that occurs anywhere in the image besides the background, your image will appear to have "holes" in it.
- Images can be **animated**. By rapidly "flipping" through a series of images, objects can be animated much as a movie simulates motion using a series of still images. This works best with line drawings but can also be done with photographs. Depending on bandwidth, the animation may not work the first time.

GIF images are limited to a maximum of 256 colors. These colors, stored in a table, index, or palette, are often referred to as **indexed colors**. When you convert a photograph to GIF format, most graphics programs will allow you to dither it. This replaces lost colors with patterns of those available in the palette. Dithering improves the appearance of the image, but it also increases the size of the file. Although GIF photographs often look OK on-screen, they suffer if compared side-by-side with images saved in JPEG and other formats. The GIF format is best used for line art such as cartoons, graphs, schematics, logos, and text that have a limited number of colors and distinct boundaries between color regions. GIF images are compressed using a "lossless" form of compression called LZW (Lempel-Ziv-Welch). The amount of compression achieved depends on the frequency of color changes in each pixel row. This is because when two or more pixels in a row have the same color, they are recorded as a single block. Hence, a picture of horizontal stripes will compress more than one of vertical stripes, because the horizontal lines would be each stored as a single block. Photographs with large areas of identical colors such as skies, snow, clouds, and so on, will compress more than images with lots of colors and patterns. To save a 24 bit image as a GIF, you must reduce the bit depth down to 8 bits. To reduce file sizes in GIF format, you can further reduce the number of colors in the image. This is difficult with most photographs, but not with line art. For example, if your image has 16 or fewer colors, you can convert it to a 4-bit (16-color) palette. Most graphics programs will allow you to do this. Even with photographs you can sometimes reduce the image to fewer colors than actually exist without noticeable loss. The discarded colors are those that are seldom-used or transitional colors between more frequent colors. When working with grayscale images, GIF works as well as JPEG because almost all programs use 8-bits (256 colors) for gray scale images.

Photo CD (.PCD)

Kodak's **Photo CD** is a Compact Disc (CD) containing image files designed to give you high quality at low cost. You can have your slides or negatives scanned onto these discs at your local photofinisher or any service bureau that offers this service. The quality you get is much higher than you would get from the most expensive digital cameras. Prices vary but range between \$1 and \$2 depending on the level of service. Once scanned onto the disc, the images can be displayed on a TV using a Photo CD player or copied into your computer from any CD drive that supports the Photo CD format (almost all now do). To help you find the image you want, the Photo CD comes with a set of index prints. These tiny prints allow you to quickly locate images and their files on the disc.



Here you see the relative sizes of the images stored on Photo CDs.

Photo CD images are stored in a file format called an **Image Pac**. An image pac actually contains thirteen individual files. These files include five different resolutions for the image (each one-quarter the size of the next largest). The files range in size from 72 kilobytes to 18 megabytes. The images are stored using the Photo YCC color encoding metric, developed by Kodak. Also included are other files used when you convert an image color from Kodak's YCC color encoding scheme to another color mode such as RGB (red, green, blue) and CMYK (cyan, magenta, yellow, and black).



Kodak's PhotoCDs have become the optical storage medium of choice for many photographic applications. Courtesy of [Kodak](http://www.kodak.com).

Photo CD disks come in a number of flavors, each designed for specific applications. Master disks come in two flavors—**Photo CD Master discs** and **Pro Photo CD Master discs**. Both can only store images that originated on film and were digitized using Kodak scanning systems and software.

- Kodak's **Photo CD Master**, developed for 35mm images, can hold about 100 images in the first five

resolutions discussed above.

- Kodak's **Pro Photo CD Master**, designed for larger film formats up to 4 x 5, includes the five resolutions on the Photo CD Master plus an optional sixth resolution of 4096 x 6144 pixels (Base*64). Depending on the film format and/or the resolution of the scan, a disc can hold between 25 and 100 images.
- The Kodak **Photo CD Portfolio II** disc is more like a multimedia disk. In addition to images, it can also store text, audio, and even software. It isn't just a storage media, but can also be programmed to give branching presentations. These discs differ from Master discs in two key respects. The images don't have to originate on film, but can also come from other sources such as digital cameras and scanners. Also, the images don't have to contain all of the resolutions stored on a Master or Pro Master disc. The highest required resolution is 512 x 768. Since only base-level images are required for this format, each Portfolio II disc can contain about 700 images, one hour of digital audio or a proportional combination (such as 350 images and 30 minutes of sound). Kodak offers two software packages to create these disks.

Arrange-It Photo CD Portfolio II imports images and frame designs from programs such as PhotoShop. You can also attach audio files (.WAV or AIFF) and specify interactive playback sequences by dragging and dropping.

Build-It Photo CD Portfolio II writes presentations to a Photo CD disc using a KODAK PCD 200 series CD writer **that has been discontinued**. Without this writer, you'll have to have a service bureau create the disc from an Arrange-It or Build-It script.

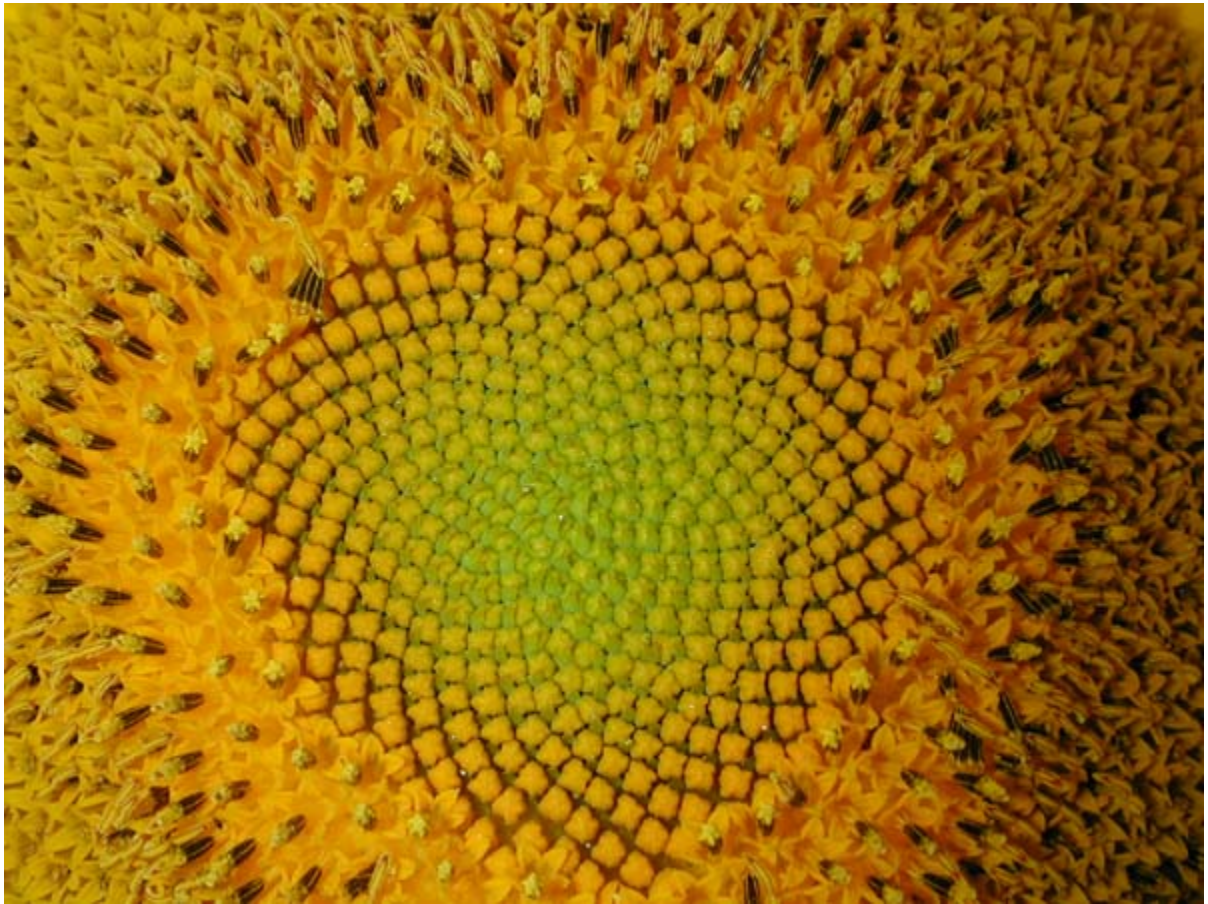
9.6 SHARPENING IMAGES

Most photos captured with a digital camera or a scanner contain some blur that can be corrected using a process called **unsharp masking** (USM). In fact, the need for this process is so common, many high-end cameras and scanners have embedded software that does it automatically. Even if it's been done once to an image, it may have to be done again if you resample the image. 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.

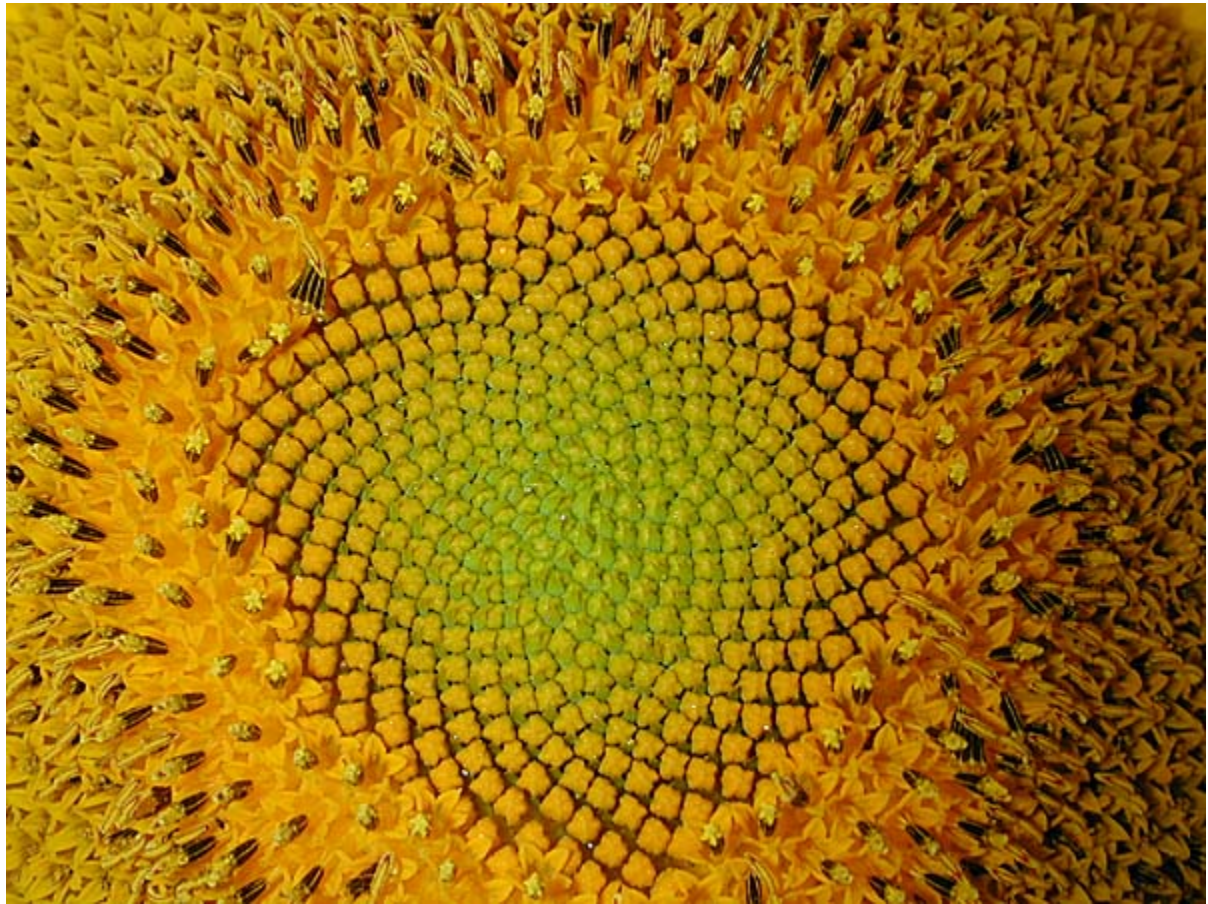
So how does the Unsharp Mask filter work? First it locates edges in the image by looking for pairs of adjacent pixels that have a specified difference in brightness (threshold) and increases the contrast of those pixels by a specified amount. The change affects not only the pair of pixels, but also any that fall within a specified radius.

- The **threshold** is the difference in brightness between two pixels before they are considered edge pixels and are sharpened by the filter. If you set the threshold value to 0, all pixels in the image will be sharpened. In some cases, such as images with flesh tones, this can introduce noise. In these cases, you might want to experiment with higher thresholds, perhaps between 2 and 20.
- The **amount** is the percentage which contrast of the edge pixels is increased. A good starting point is around 100%.
- The **radius** is the number of pixels around the edge that are sharpened. To begin, you might try a radius between 1 and 2 pixels.

When sharpening an image, keep in mind that the effects of the Unsharp Mask filter are more obvious on the screen than in high-resolution output. To get a feeling for the effects, do some experiments and sample printouts to see what settings work best for you.



An unsharpened image of a subflower blossom.



Sharpened image.

TIP: Colors too Saturated

If the Unsharp Mask filter makes bright colors in your image look too saturated, you can sharpen the image without affecting the color components. To do so, convert the image to LAB mode and then apply the filter only to the L channel. In LAB mode the lightness and darkness information is in a channel separate from the color information so you can apply the Unsharp Mask filter only to that channel. Since this doesn't effect the color information, you can sharpen an image more.

9.7 RESIZING IMAGES

The size of an image is measured by the number of pixels it contains. To reduce an image, you reduce the number of pixels in it. To enlarge an image, you add pixels. Both of these processes are referred to as resizing the image. Reducing an image almost always has less affect on its appearance than does enlarging one. This is because, enlarging requires the program to add pixels. To do so, the computer analyzes adjoining pixels to determine the color of any new ones it inserts. Normally, you can double the size of an image without effects showing. However, trial and error is usually the only way to see because images vary so much.



200 x 133 pixels



100 x 67 pixels

9.8 CROPPING IMAGES

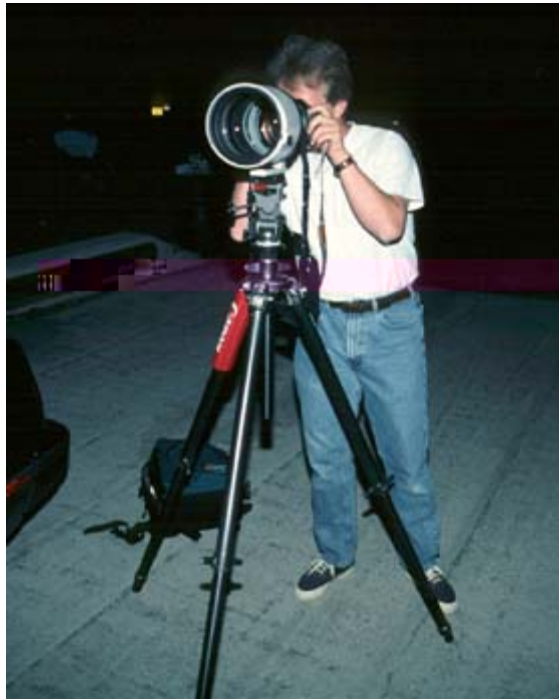
Great photographers try to compose, capture, and then print images full-frame. However, editors and others love to crop images to fit unusual shapes in layouts, or to make the image more dramatic. It's like looking for a better photograph within a photograph. At other times, you crop to straighten a horizon line, remove distracting elements, or enlarge small portions.

To evaluate an image for cropping, make a printout. Then cut two "L" shapes from a piece of paper or cardboard large enough to cover the photograph you're evaluating. By arranging the L's in various configurations, and size and shape rectangle can be formed to isolate a portion of the image. When you decide how you want to crop, mark straight lines onto the print to use as a guide when cropping in your photo editing program.

As with film photography, cropping reduces the area of the image to be enlarged. The greater the enlargement, the more blur, grain, and other faults show. Try to shoot images full-frame so you don't have to crop them later. Professionals have always tried to do this, and it's only in photojournalism and the graphic arts where a lot of cropping goes on as editors and designers look for images within images.



The original image has too much dark space around the center of interest.



Cropping, cuts out the dark areas, leaving just the interesting part of the image.

9.9 ROTATING IMAGES

If an image becomes rotated in the frame during capture or scanning, you can rotate it back to a vertical or horizontal position. When you use this command, you'll always lose a part of the image when you crop the edges to make the edges of the rotated image square or rectangular again.



The horizon line in front of the mountains is slightly tilted as is the tall cactus in the foreground.



The rotation command has been used to level the image.

9.10 CHANGING BRIGHTNESS AND CONTRAST

In a darkroom, you control for brightness by changing exposure times and contrast by your selection of papers or filters. In digital photography these are usually controlled by dragging slider bars. To understand what effects these have, just change the brightness and contrast settings on your monitor.

9.11 ADJUSTING COLOR BALANCE

Color balance (or hue balance) can change the relationships of the red, green, or blue channels to make the colors in an image more accurate or more different.



The original image has a gray cast to it.



By adjusting color balance, the image is given a more surrealistic look.

9.12 SATURATION

Saturation refers to the intensity of a color. This feature is often used with color balance to vary the intensity of specific color levels to get those color photos looking just right.

9.13 USING FILTERS

Filters are used to manipulate images in preset



ways.

This photograph of a mission in Arizona has been filtered to make it look like a watercolor painting.

9.14 COMPOSITE IMAGING

There was a time when photos were called "faithful witnesses" because they represented reality. This was really never true, but now the ability to manipulate photos is within the reach of anyone with a photo editing program and a little patience. To see what you can do when you're really good, check out [Mike Berceanu's](http://www.berceanu.com.au/) home page (<http://www.berceanu.com.au/>).

CHAPTER 10, PRINTING IMAGES



Introduction

As Ansel Adams said "The negative is the score, the print is the performance." This is just as true in today's digital world as it was in Ansel's silver-based one. If you haven't seen photographs printed on color printers, you are in for a big surprise. The output you can get from printers costing a few hundred dollars will shock you. The results may not be the same as prints made with traditional photography, but in many ways they have a look and feel all their own. Because of the wide choice of papers, inks, and technologies available, printed images vary a lot. This doesn't mean they have poor quality, it just means they are different. At the moment, two types of printers stand out, ink-jets for low cost and dye subs for high quality. Before looking at them in more detail, let's look at how printers work.

10.1 HOW COLOR IMAGES ARE PRINTED

Color printers create images by dividing a page into thousands, or even millions, of tiny dots, each of which can be addressed by the computer. As the printer moves across and down the page, it can print a dot of color, print two or three colors on top of each other, or leave the spot blank (white). To understand digital printing, you need to know a little about the colors that are used and the patterns in which they are printed.

CMYK Colors

As you've seen, color displays use three colors, red, green, and blue (RGB) to create color images on the screen. This process is referred to as additive color because adding all three colors together forms white. Color printers use a different process, called subtractive color. This process uses three subtractive primaries—cyan, magenta and yellow. When two of these are overprinted, they form red, green, or blue. When all three are overprinted, they form black. Most printers include a separate black color to provide a deeper black than that formed by combining the primaries. This is useful, not only for richer blacks in photographs, but also when printing text. These four colors give the color system its name—**CMYK** (C for cyan, M for magenta, Y for yellow, and K for black). If your browser has a Shockwave plug-in, you can assemble a full-color image from the three basic colors at [Konica's site in Japan](#).



When you use cyan, magenta, and yellow inks or pigments, you create subtractive colors.

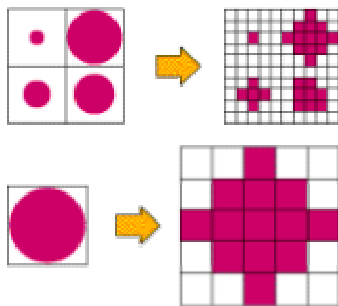
By leaving a spot blank, or by using one or more of the three subtractive primaries on a single dot, the printer can create eight primary colors as follows:

Color 1	Color 2	Color 3	Combined
White	White	White	White
Cyan	None	None	Cyan
Magenta	None	None	Magenta
Yellow	None	None	Yellow
Cyan	Magenta	None	Blue
Cyan	Yellow	None	Green
Magenta	Yellow	None	Red
Cyan	Magenta	Yellow	Black

Halftones and Dithers

On most printers (dye-sub is an exception), each printed dot has the same density of color. If the printer only combined these solid colors, it would be limited to the eight primary colors describe above. To get the millions of colors in a photograph, the printer has to "fake" it by generating a pattern of small dots that the eye blends to form the desired shade. This process is called **halftoning** or **dithering** and designing printer software that does it well is as much art as it is science. As a result, printers vary widely in the methods used and the results obtained. One sign of halftoning being well done is when a smooth gradation of color in the original looks smooth in the print. If the process isn't well done, these smooth transitions will be made up of distinct bands of color and may also include moiré or doily patterns.

Halftoning is done by arranging printable dots into grid-like groups, called **cells**, and then using these larger dots as a single unit to print pixels with. Each cell may be 5 by 5 or 8 by 8 dots in size. The three or four primary colors are printed combined in a pattern of dots in these cells, and the eye perceives them as intermediate hues. For example, to print purple the printer uses a combination of magenta and cyan dots. For less saturated hues, the printer leaves some dots unprinted and hence white in color.



The printed forms on the left in each picture are actually made up of square pixels as shown in the right-hand objects. Courtesy of [Tektronix](#)

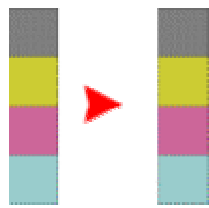
Halftoning has long been used in the conventional printing industry and you can see it by looking at a magazine photo with a magnifying glass. It is also embedded in page description languages such as Adobe's PostScript Level 2. However, printer manufacturers try to improve on these standards with their own proprietary systems that are better matched to their printers.

Color Gamut

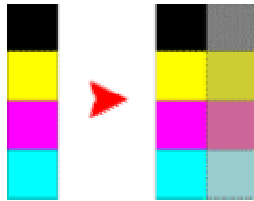
Color gamut refers to the range of colors that can be reproduced by any device.

Unfortunately for photographer's mother nature's color gamut is a lot larger than any we can reproduce with light, inks, dyes, or pigments. The best we can do is get as close to the original scene as possible. Your first experience with the limitations of color gamut is if you shoot both slide and print film. The slides are always richer and brighter than the prints because slide film has a larger color gamut.

One way to think of color gamut is to imagine that you have a set of dull inks. You're asked to use them to print bright colors. It can't be done because the color gamut of the inks is smaller than the color gamut you're asked to create. On the other hand, if you have a set of bright inks, you can reproduce the colors of the dull inks because they fall within the color gamut of the inks you're using.



Dull inks with a small gamut only let you create dull colors.



Bright inks with a large gamut allow you to create both dull and bright colors.

When reproducing colors on the screen or printed page, we use what are called **color models**. One model, called **Lab**, has the largest gamut. Within the color model can be found all of the colors of the two most popular color models: RGB and CMYK. The RGB gamut includes only those colors that can be displayed on a computer screen. Some colors, such as pure cyan or pure yellow, can't be displayed accurately on a monitor. The CMYK model, used for printing, has the smallest gamut. When colors in an image can not be displayed or printed because they aren't in a device's gamut, they are called **out-of-gamut colors**.

Until recently, there were no inexpensive color printers but great strides have been made over the past few years. There are now a variety of printers at a variety of price points. When you choose a printer to print photographs, it's not always the most expensive kinds that give the best looking results. Let's take a look at some of the ways printers transfer images to the page.

10.2 TYPES OF PRINTERS

There are a number of different printer technologies on the market and each has its own niche. In the vast majority of the market right now, the ink-jet printer is king.

Liquid Ink-jet Printers

Liquid ink-jet printers propel fine droplets of liquid ink toward the surface of paper. In today's marketplace, this technology is the low-cost entry point for personal printing and low-volume color printing.



Tektronix's Phaser 140 is an ink-jet printer. Courtesy of [Tektronix](#).

Quality

These low-cost printers do an amazing job of printing photo-realistic images on a wide variety of papers.



The Epson Stylus 800 is a photo quality ink-jet printer that prints 1440 dots per inch for less than \$400. Courtesy of [Epson](#).

Materials

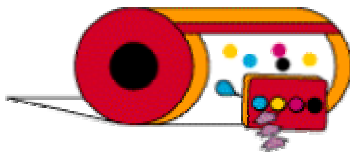
find that liquid inks tend to soak into the paper taking the color along with them. You'll get richer colors using coated papers that are less absorbent and designed specifically for photographs. The ink dries partly by absorption and partly by evaporation. If the paper is too absorbent, the image looks washed out.



Ink cartridges courtesy of [Tektronix](#).

Transfer Process

A cartridge of ink is attached to a print head with up to hundreds of nozzles, each thinner than a human hair. The number of nozzles and the size of each determines the printer's resolution. As the print head moves across the paper, a digital signal from the computer tells each nozzle when to propel a drop of ink onto the paper. On some printers, this is done with mechanical vibrations. Piezoelectric crystals change shape when a voltage is applied to them. As they do so, they force ink through the nozzles onto the paper. Each pixel in the image can be made up of a number of tiny drops of ink. The smaller the droplets, and the more of them, the richer and deeper the colors should be.



*Piezoelectric crystals force ink through the nozzles onto the paper.
Courtesy of [Tektronix](#).*

Inkjet printing, like conventional printing on a press, is binary. These printers can only put ink down or not put ink down. They can't control the density of each dot. To achieve the illusion of continuous tones, the percentage of area covered by ink is modulated in one or both of two ways:

1. A screening process maps the desired variations in density into variations in dot size. Thus, as the desired density increases, the dot sizes increase and a higher percentage of the white space is covered with ink.
2. If the printing process supports smaller dots of a fixed size, area modulation is achieved by varying the number (rather than the size) of dots that are printed in any given small area.

There are two pitches of concern with such printing: the dot pitch and the screen pitch. For example, an inkjet printer may have a raw dot pitch of 1200 dpi. An equivalent screen pitch may be defined as say, 75 lpi, where "lpi" refers to the equivalent dot pitch of a screen (lines per inch). Thus, each screen cell (75/inch x 75/inch) contains $1200/75 \times 1200/75 = 64$ raw dots. In such a case, each screen cell could be printed at any of 65 levels (0 to 64 dots). This process would then be equivalent to a 65 level, 75 pixel/inch printer.

Dye Sublimation Printers

At the high end where quality is very important, you'll find dye-sublimation printers (called dye-sub, but more accurately dye-diffusion). The "dye" in the name comes from the fact that the process uses solid dyes instead of inks or toner. "Sublimation" is the scientific term for a process where solids (in this case dyes) are converted into a gas without going through an intervening liquid phase.



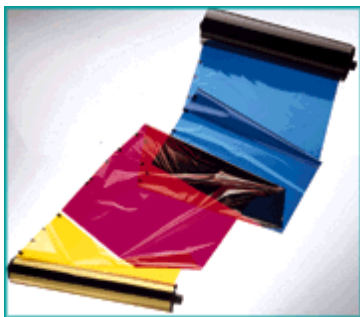
The Phaser 450 courtesy of [Tektronix](#).

Quality

When printing color photographs, there's nothing like dye sublimation printers. These printers produce photo-realistic continuous-tone images that look like they came from a photo lab.

Materials

Dye sub printers have their colored dyes in a transfer roll or ribbon. This roll contains consecutive page-sized panels of cyan, magenta, yellow and black dye. (A three-color transfer roll produces blacks that are a composite of CMY but they are not as rich.) These printers require special paper that's designed to absorb the vaporous dye on contact. Cost per page is high, \$3 to \$4 dollars for a letter sized page.



Tektronix offers three high-quality transfer rolls for the Phaser 450. Each roll consists of page-sized panels of ink that are passed over a tightly focused heating element and diffused onto dye sublimation paper or transparency film. Courtesy of [Tektronix](#).

Transfer Process

During printing, separate passes are made across the print for each of the four colors—cyan, magenta, yellow, and black. (Maintaining accurate registration for each color requires precise paper feeding one reason these machines are costly.) A thermal print head, consisting of thousands of heating elements, contacts the media being printed on and vaporizes the solid dyes. The resulting gas diffuses into the surface of the paper. What makes these printers unique is that the heating elements on print head can be set to any one of 256 temperatures. The hotter the temperature, the more dye is transferred to the paper. This precise control of the amount of dye that's vaporized controls the density or intensity of the resulting dot on the

paper and produces continuous-tone images.



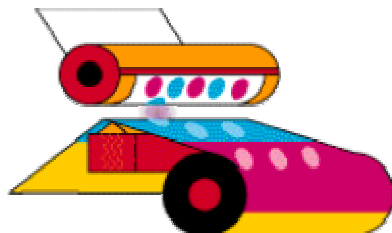
The hotter the print head, the more dye and denser the pixel. Courtesy of [Tektronix](#).

A dye-sub printer prints square dots each of which is denser in the center and lighter on the perimeter. By varying the amount of power delivered to the printhead for each dot, the amount of dye transferred to each dot and hence the dot's density can be varied from no dot at all, to a small light dot, up to a large dense dot. Because the size of the dots doesn't change, the colored parts of the smaller dots have white space between them. At higher energies, the colored areas of each dot become larger and denser, eventually merging into the adjacent dots.

Because the dyes are transparent, a cyan dot may be printed on top of a magenta dot to make a blue dot. By varying the amount of C, Y, and M, any color within the printer's color gamut may be produced.

Black (K) is normally used in these printers only for text, although it may sometimes be used within a continuous-tone (contone) image via the process known as "undercolor removal." (Calculating how much cyan, magenta, and yellow from the image and how much black to add to it.)

Because they can vary the density of each color, dye-sub printers are the only ones that don't have to use halftoning or dithering to create a wide range of colors. And because there are no dithered dot patterns, the colors are applied in a continuous tone; hence the photorealistic images.



Courtesy of [Tektronix](#).

Despite their name, most dye-sub printers actually work by dye diffusion, not by sublimation. Early in the development of these printers it was mistakenly believed that the dyes were transferred by sublimation. However, the dyes are actually transferred by diffusion from the ribbon to the media. This diffusion is activated by two processes; heat from the printhead and pressure in the printing region. Springs or weights force the printhead to push the inked ribbon into contact with the media, so that diffusion can occur. A more accurate term for this process is actually "Dye Diffusion Thermal" or "D2T" printing. There are some high-end printers such as Kodak's "Approval" system, which do work by sublimation. These printers use a laser to vaporize the dye, which then deposits itself on the media and solidifies. Such printers are the exception rather than the rule, and are capable of very high dot pitch, up to 3000 dpi.

Solid Ink-jet Printers

Solid ink-jet printers are great for producing reports and publications with color graphs or other graphics on ordinary paper. They are also the hands-down winner for producing high-

quality transparencies at low cost. And, if you're producing a black-and-white document with just a page or two of color charts, you can do so without having to print the charts on a special paper that stands out from the rest of the document.

Quality

Solid ink-jet printers produce high-quality images with sharp edges and good color reproduction.



Tektronix's Phaser 300X color printer can handle any paper you'd like: 16-lb. bond to 80-lb. cover. Letterhead, book, text, writing, cover stock, drafting vellum, recycled, or anything else that looks interesting. It's the world's most versatile color printer. Courtesy of [Tektronix](#).

Materials

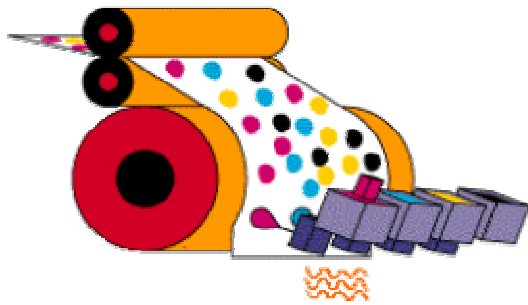
Cyan, Magenta, Yellow, and Black color sticks (solid bricks—a bit like colored bars of soap) are installed in the printer. Solid ink printers can print on nearly any kind of paper stock, an important feature if you make color proofs. For example; if you are a package designer, you can simulate the appearance of a new design for your client by outputting the proof on the same stock as the final packaging. Solid ink printers work well with colored stock. These printers apply extremely vibrant and opaque color and are ideal for graphics.



Ink sticks courtesy of [Tektronix](#).

Transfer Process

Solid ink-jet printers use solid ink sticks that are melted into a reservoir and sprayed through tiny nozzles onto the page where it immediately hardens. (These are sometimes referred to as phase-change printers because the ink moves from a solid to a liquid phase to be printed then back to a solid phase on the page.) As a final step, the paper moves between two rollers to cold-fuse the image.



Courtesy of [Tektronix](#).

Thermal Wax Printers

Thermal-wax transfer was once the workhorse of print technologies, and can still be a very effective technology. Thermal-Wax printers are fast, deliver vibrant colors, are great for printing presentation graphics and the per-page cost is low.

Quality

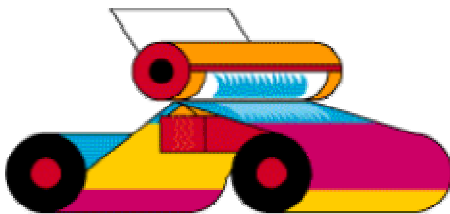
Thermal-wax printing can produce vivid colors on a variety of office laser papers but the quality of continuous tone images does not approach that of dye-sub printers.

Materials

Instead of inks, thermal-wax printing uses a transfer roll or ribbon of colored wax that is segmented into page-sized sections each of the three subtractive colors (and optionally, black). The paper is a special paper but you can also use transparency film. Thermal Wax Transfer is one of the most widely used processes in scientific, technical, and business printing.

Transfer Process

As the ribbon coated with cyan, magenta, yellow and black wax, in page-sized panels is moved over a thermal printhead, thousands of heating elements on the printhead, capable of precise temperature variations, causes the wax to melt and adhere to specially coated paper or transparency material. The final printed image is composed of tiny dots of colored wax.



Courtesy of [Tektronix](#).

Color Laser Printers

Laser printers revolutionized black-and-white printing, making graphics and desktop publishing possible. However, color laser printers on the margins of photographic printing. Not only are their costs high, but their quality has not yet matched the very inexpensive ink-jet printers.



Tektronix's Phaser® 360 Color Printer is the first Adobe® PostScript® 3 color printer. [Courtesy of Tektronix.](#)

Quality

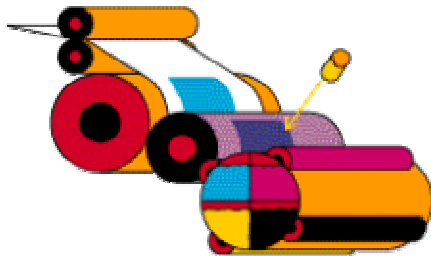
Photographs printed on a color laser can be good and the best can rival the photo-realistic images created with dye sublimation printers. The toner is also fairly durable and it's less sensitive to fading from exposure to light than some other technologies.

Materials

The colors for laser printing are contained in four separate toner cartridges, one each for cyan, magenta, yellow and black. No special paper is required, but you can use different kinds to change the "look" of the print.

Transfer Process

Laser printers use a technology similar to that used in copiers. A laser beam is focused on a photoelectric belt or drum, creating an electrical charge in areas where toner is to adhere. Charged toner is then attracted to those places on the belt or drum. Electrostatic charges cause the toners to adhere to the belt. With black and white printers, this process happens once but with color printers it is repeated for the cyan, magenta, yellow and black components of the image. The image, composed of the four toner colors, is then transferred to a drum which rolls the toners onto the sheet of paper or transparency. The toners on the paper are then fused using either heat or a combination of heat and pressure.



Color laser courtesy of [Tektronix.](#)

Other Printers

Now that you understand a little about how printers work and what your choices are, let's look at some specific printers. These aren't the typical laser, ink-jet, or dye-sub printers you find in stores and catalogs. They are variations on these themes.

Thermo Autochrome

The [TruPhoto Digital Photo Printer](#) (4" x 6") uses a technology termed Thermo Autochrome. This process uses a thermal head and ultra violet light to process pigments in the paper. There are three layers of colors in the paper, yellow, magenta and cyan. Each color has sensitivity to a temperature. Yellow reacts to a low temperature while cyan reacts to the high temperature and magenta is in the middle. The printer passes the paper past the thermal head 3 times. The first pass heats the yellow layer then the ultra violet light fixes the yellow so that it can no longer be processed. The second pass heats the magenta and the ultra violet light fixes it. The third pass heats the cyan, there is no fixation after the cyan heating. This process is a continuous tone and does not use any other median other than heat, light and TA paper.

- TA prints are permanent and resistant to fading.
- TA paper is the only consumable. Ink jet printers use 4-6 inks released from a jet onto the paper.
- Ink jet printers use dithering Inks can rub off onto another median.
- Dye-sublimation printers use a ribbon to transfer color to the surface and it can be rubbed off

Snapshot Printers

Snapshot printers can use any printing technology but generally makes prints that are smaller than 8 x 10. Many have a lower resolution than their larger cousins. Their prints look good but when placed side-by-side with chemically produced prints, you may notice that they aren't as clear and colorful and yet they cost more than prints. Some of these printers connect directly to cameras so you can bypass the computer altogether.



The Olympus P-300 Personal Photo printer prints 4" x 5.5", 300 dpi, photo-quality dye-sublimation prints in true 24-bit color at a rate of 1.5 minutes per print. Courtesy of [Olympus](#).

The Fujix Pictography Printers

The [Fujix Pictography](#)™ 3000 printer creates silver-halide, 24 bit images with the full depth and richness of a traditional color photographic print. Joel Meyerowitz uses one of these printers.

Printing Services

When it comes to the really high-quality or unusual printer, it's unlikely that you'll want to

own one due to the cost. However, there are places that offer digital printing services that you can take advantage of.

Kodak Picture Makers

In camera stores, you may have seen Kodak Picture Makers. These easy to operate, self-service printers make prints from prints, slides, negatives, photo CD discs, Digital camera memory cards, and JPEG and FlashPix-format floppy diskettes. To do this, the station has integrated drives, scanners, printers, and a display monitor. Before making a print, you can zoom and crop, use red-eye reduction, adjust color and density, and add mattes and borders. You do all of this by making simple choices displayed on a touch-sensitive screen.



The Kodak Picture Maker makes incredible prints from slides, negatives, prints, or digital files. Courtesy of [Kodak](#).

Large Format

When you want poster-sized prints, you have to locate a large format ink-jet printer. These printers feed large sheets of paper much like a plotter and the ink-jet printing head lays down lines of ink as the paper passes through the printer. One large format printer from [HP](#) prints 2' by 3' images at 600 dpi. Generally you'll find these printers at service bureaus where they'll charge you by the size of the print.



The Tektronix Phaser 600 is a solid ink printer that can print a 34" x 44" print in 12 minutes in Standard mode and 24 minutes in Enhanced mode. Courtesy of [Tektronix](#).

Iris Prints

Iris inkjet printers were originally developed for printing proofs in the printing industry but have been adapted to art uses. Images from these printers have a photo-realistic quality and amazing dynamic range. Using only four ink nozzles, one for each CMYK color, they can print up to 300 dpi in such a way that it visually simulates an 1800 dpi print. They do this by

matrix. And color quality isn't their only advantage, they can also print on large, thick material such as heavy artists water-color paper, polyester, cloth, and most other materials that will accept water-base inks. In some corners of the art world, Iris ink-jet prints are called "giclée" prints on the assumption that if it sounds French it sounds like art. However, the term "Giclée" means "squirt or spurt," hardly an art-like term. The first use of this printer for art prints is credited to the rock musician Graham Nash. Nash, working with printmaker Jack Duganne and a friend R. Mac Holbert formed a company called Nash Editions Ltd. in Manhattan Beach, California in 1991. Because of the use of these printers for expensive art prints, a lot of effort has gone into fade-resistant inks and UV protective layers that ensure a print's longevity. How successful these efforts have been, only time will tell.



Iris 3047HS courtesy of [Scitex](#).

Fiery

Fiery Color Servers from [Electronics for Imaging](#) (EFI) turn standard digital color copiers into networked color printers that produces brilliant, photographic-quality images at an affordable price. You'll find these systems at many service bureaus. These systems are also used to scan photographs and images on the copier, manipulated on your desktop, then printed back via the copier that scanned them. The Fiery XJ+ Color Server has a built-in color management system that gives you control of color from screen to document. Fiery technology is also available as the XJe embedded controller. The XJe is embedded in desktop color laser printers from Canon, Digital and IBM as well as in the new Ricoh Aficio 2000 series digital color copiers.



The Fiery® ZX™ Servers drive high-speed color copiers and black and white digital presses. Courtesy of [efi](#).

Film Recorders

Film recorders, also called film printers, are used to create slides, prints or chomes directly from your desktop.



The Polaroid ProPallette creates 35mm positives and negatives with photographic-quality. Prints with up to 8000 lines of resolution. Courtesy of [Polaroid](#).

10.3 PAPERS AND INKS

Papers and inks have affects on both the initial image quality and eventual archival quality. When images fade, memories are lost. This has been a problem throughout the history of photography. Most papers, inks, and toners have unknown archival qualities. If you have the original digital file, this is no problem. But will you be able to find it ten years from now? And if you can, will the media still be readable. No media is permanent and you may be out of luck.

To check on the archival quality of printers, you might want to visit [Wilhelm Imaging Research, Inc](#) or

[International Association of Fine art Digital printers.](#)

Artists care much more about longevity than commercial users because their prints are expected to last as long as possible in private and museum collections. A [comparative table of print processes](#) can be found at Wilhelm's site.

Papers

Color photographs printed on regular paper with an ink-jet printer lack density, contrast, brilliance, and sharpness. Part of this problem is due to the paper itself. Its surface is rough, dull and absorbs ink. If you look at a photographic print, you'll see that the paper is brighter, heavier, and the surface is smoother and less porous. Your ink-jet prints can get much closer to photographic print quality if you print on special photographic printing paper. These inkjet papers are specially coated, glossy, and heavier to make it look and feel very much like conventional photo paper. You can also use transparency film that has a special coating to give you bold, vibrant colors and sharp text. Your choices are amazing and have a huge affect on your results. Shop around on the Web, or visit your local computer or office supply store to see what's available.

Fine Arts Papers

Digital images can be printed on a wide variety of materials ranging from metal to paper. Because of the wide range of possible materials, the generic term "substrate" is used for the media on which we print. The term "substrate" literally means, "the surface on which an organism lives." In the case of paper, a substrate begins as a base product produced by a paper mill. This raw product is then coated with different water and solvent based solutions to give it characteristics that allow it to accept an inkjet print.

As photographers become more concerned with the longevity of their digital prints, fine art papers are becoming more popular. These papers, already widely used in the arts world for prints and paintings, last hundreds of years. When you use these papers for digital photographs the issue is the ink stability, not the stability of the paper. Paper makers are working on papers that will interact most effectively with the water-soluble inks used for digital printmaking.

Fine Art Media vs. Conventional Media

There is a distinct difference between conventional photo grade paper and fine art paper. Fine art media is not only more substantial and richly textured, it's long-lasting. Fine art media is typically made from 100% cotton (except canvas which is usually 50% cotton & 50% polyester). It's also acid-free and buffered against atmospheric acids. (Buffering neutralizes acids in the paper or environment using an alkaline substance such as usually calcium carbonate.) The media will last for centuries while providing a rich and elegant look. Virtually all fine art media are made by the same traditional methods that have been in use for hundreds of years. The materials used in these unique crafting methodologies are simple and pure and the process is environmentally friendly.

Why use Fine Art Media? The weight or thickness of fine art media is one key consideration. If you close your eyes and feel most typical inkjet media, you will realize that the differences between them are negligible. When you close your eyes and feel fine art media, the textures and the thickness in the stock are immediately apparent. The difference is like comparing a blade of grass to a rose petal. These unique substantive properties make fine art media the best choice for framing and display work.

Who is using Fine Art Media? Most users of desktop fine art media are professional photographers, graphics artists, and artists. However, more and more amateur photographers and desktop publishers are using fine art media to make their work unique and highly distinguishable from the work of their friends or competitors. Photographers and artists can publish promotional and presentation pieces or self-publish their work with desktop systems and fine art media. Several photographic and artists studios are also beginning to use an array of desktop printers in creating archival prints. They are finding that in some cases, the results can be equivalent to prints produced with more expensive methodologies.

Unique Properties

Henry Wilhelm of [Wilhelm Imaging Research Inc.](#) determined that coated papers don't have the archival properties of non-coated papers and thus coated papers are not truly considered a fine art media. When ink is applied to a coated paper, it's not absorbed as much. The ink on coated paper is raised and therefore exposed more to chemical agents in the atmosphere, leading to quicker degradation. Prints on coated paper can be fabulous in the short term but do not lend themselves to archival usage. Uncoated papers such as Arches Cold Press and Somerset Velvet provide the best interaction with archival inks. Arches Cold Press Paper, which provides the greatest longevity when used with the most permanent ink sets—currently Iris Equipoise and Lyson Fine Art—works well with these inks because of three factors: surface, whiteness, and the amount to which the ink spreads after it hits the paper.

The whiteness of the paper also affects the image: the whiter the paper, the greater the color contrast between it and the ink. For example, Arches paper has been used in printmaking for hundreds of years. Although it is incredibly stable, it did turn color slightly from white to light ivory as it aged. Today the paper's pH has been slightly lowered to counteract that change so this very white paper will retain its whiteness over the years. How much the dot of ink spreads when it hits the surface of the paper affects image clarity and printability. The reason Arches performs so well is that it allows very little spreading of the ink, to create a sharper image.

Somerset papers are also high on the list for printmakers. They still offer a high ink

longevity, 20-40 years before noticeable fading occurs and are available in a variety of finishes: velvet, satin, rough and textured. Printmakers and artists have a lot of options to play with.

Most desktop fine art papers in use are papers that are currently being used in high-end digital printing. Somerset for example is the standard paper used in Iris printing. Papers designed specifically for the digital printmaker are just now becoming available and are ideal for the water-based dyes used in most inkjet printers. The pH of these papers is higher, something that's good for the paper, but not for the inks. There are also papers being designed that have pushed the pH down a bit, made the sheet as white as possible and added a water-resistant seal to the paper fibers for longevity.

[International Association of Fine art Digital printmakers](#)

The objectives of the [IAFADP](#) are to encourage and support the development of the fine art digital printmaking industry. The group will develop standards, definitions and practices intended to promote the orderly integration of developing digital technology into the fine art industry. The function of the group will be to educate the industry while driving research on issues such as the stability of digital prints. The Association will also share information of new technologies, color management methods, and methods to enhance the quality of printmaking

Inks and Longevity

As with papers, there are two important points about inks: their quality and their durability. Most inks fade very quickly when exposed to direct sunlight. However, most also fade in dim light so you can't count on hanging them on the wall for years like you can traditional photographs. Inks are improving and some, like [Ilfojet Archiva Ink](#) will last 20 years before fading 25%. Some printers place a protective film over the final image to protect it from mechanical abrasion and from UV light that would otherwise fade the image over time.

Dye diffusion printing uses transparent dyes. Ink jet printers also use transparent dyes, or in some cases, transparent pigments. A dye is a colorant that is dissolved in the ink, while a pigment is a suspension of colorant particles.

The [Luminos Photo Corporation](#) carries a line of inkjet photographic papers and inks that have been designed to produce prints that will resist fading in indoor lighting. Their Lumijet Fine Art Preservation Series Media uses "an ink-receiving layer that does not impair the fade resistant characteristics" of their new Lumijet Fine Art Preservation Inks. The color Preservation Inks are available in two different sets for Epson inkjet printers.

- Preservation Platinum, is said to have a fade resistance of 65-70 years when used with the Preservation Series Media under "average display conditions."
- Preservation Silver offers an average display life of 25-30 years.

The papers, in sizes from 8.5"x11" to 17"x22", include Gallery Gloss with the look and feel of conventional glossy photographic paper; Soft Suede with a soft matte finish; Classic Velour with a velvet-like feel; Flaxen Weave that replicates the fabric used in Renaissance wall hangings; and Museum Parchment, which resembles parchment paper.

One thing you may have noticed about inks is their high price. Printer manufacturers often price their printers low and make their big money in the consumables. It's the old razor/razor blade concept. They try to increase their profits in two ways: selling all colors in a combined package and keeping you tied to their own inks. Most printers print images using CMYK, so there are four colors of inks: cyan, magenta, yellow, and black. Most printers have a separate black cartridge but combine the cyan, magenta, and yellow into a single cartridge. Rarely if ever, will all three of these colors be consumed at the same rate. For example, if you're printing construction signs, the yellow ink is used long before the cyan and magenta. However, if all colors are in a single unit, you have to replace the entire cartridge. Better printers allow you to replace just the used up color. To keep you from using less expensive inks from other manufacturers, printer companies often tell you that doing so will void your warranty. Forcing you to buy consumables only from them is called a **tie-in sales provision**. In the box below is a direct quote of what the [U.S. Federal Trade Commission](#) advises manufacturers about such provisions. (The provisions in your country may vary.) If you run into a situation where the printer company tells you you must use their inks, request from them a copy of the waiver they received from the warranty staff of the FTC's Bureau of Consumer Protection that allows them to use a "tie-in sales" prohibition.

Tie-In Sales Provisions

Generally, tie-in sales provisions are not allowed. Such a provision would require a purchaser of the warranted product to buy an item or service from a particular company to use with the warranted product in order to be eligible to receive a remedy under the warranty. The following are examples of prohibited tie-in sales provisions.

In order to keep your new Plenum Brand Vacuum Cleaner warranty in effect, you must use genuine Plenum Brand Filter Bags. Failure to have scheduled maintenance performed, at your expense, by the Great American Maintenance Company, Inc., voids this warranty.

While you cannot use a tie-in sales provision, your warranty need not cover use of replacement parts, repairs, or maintenance that is inappropriate for your product. The following is an example of a permissible provision that excludes coverage of such things.

While necessary maintenance or repairs on your AudioMundo Stereo System can be performed by any company, we recommend that you use only authorized AudioMundo dealers. Improper or incorrectly performed maintenance or repair voids this warranty.

Although tie-in sales provisions generally are not allowed, you can include such a provision in your warranty if you can demonstrate to the satisfaction of the FTC that your product will not work properly without a specified item or service. If you believe that this is the case, you should contact the warranty staff of the FTC's Bureau of Consumer Protection for information on how to apply for a waiver of the tie-in sales prohibition.

10.4 COLOR MANAGEMENT

As images pass from scanners to screens, and then to printers or Web pages, the colors shift about because each device has its own unique way of defining and displaying them. For the same reason, images edited on your screen, posted to the Web, and then viewed on your screen look different. They also look different if you print the Web page on your printer and someone on the other side of the world prints it on theirs. To try to make colors more consistent across a range of devices, color management systems are used. However, even then colors will never match perfectly for a number of reasons. Some of these include the following:

- The screen and printer use different color systems—RGB on the screen and CMYK on the page. RGB produces colors, not with pigments or inks, but by combining red, green, and blue light sources. CMYK reproduces colors by combining pigments or inks. The results are viewed in reflected light. When you print an image displayed on the screen, the RGB must be converted to CMYK and that process isn't perfect.
- Experienced photographers know that slides have more contrast and color richness than prints do. This is because slides are viewed by transmitted light and prints by reflected light. The same is true of a display monitor and printout. An image displayed by transmitted light on the monitor is going to be better than one viewed by reflected light on a piece of paper.
- Displays don't have to use halftoning to create colors because they can vary the intensity of color at each pixel. (The only printer type that can do this is the dye-sub.) Each pixel contains three phosphors—one each for red, green and blue. To display a red object, the monitor uses an electron gun to "turn on" the red phosphors in the appropriate area. Turning on all the phosphors produces white. To create shades of color, the monitor's electron gun can be controlled in eight steps for each of the three phosphors, for a total of 24 steps for each pixel.

To make your prints more closely match what you see on the screen, you can make a printout and then use it as a guide when adjusting the screen colors. However, you may now be looking at an image on the screen that you don't like. In some cases, it's hard to make the mental adjustment required to edit the "false" colors on the screen. To get serious about matching screen to print colors, you need a **color management system (CMS)**. Without such a system, colors change as they move from stage to stage in the imaging process.

What's a Color Management System?

Color management systems are designed to keep the colors of your images as consistent as possible through capturing or scanning, displaying, and printing. They specify colors in terms of an objective, device-independent standard rather than in device-dependent terms such as RGB or CMYK. These color management systems include:

- Microsoft Image Color Management 2.0 (ICM) is based on Linotype-Hell's LinoColorCMM (Color Management Module) already used in Apple's ColorSync. This means color consistency is achievable in NT and mixed Windows and Mac environments.
- Kodak Digital Science Color management System.
- CIELAB (The Commission Internationale de L'Eclairage) also known as L^*A^*B .
- HiFi Color
- Kodak's YCC color space is based on a 1950s TV color model. It can be easily converted to other color

models with varying losses of color values.

- The PANTONE® Matching System.
- PostScript Level 2 which uses the international color standard known as CIE XYZ, developed by the Commission Internationale de l' Eclairage (International Commission on Illumination).
- EfiColor™ from Electronics for Imaging, Inc. (EFI)
- [ColorSync](#)™ from Apple Computer, Inc is now supported by Microsoft's Internet Explorer 4 so color management now extends to the Web.
- ColorSense™ from Kodak.

What's a Color Model and Color Space?

As a photographer, you've seen colors change as the source of the light changes. It even changes out of doors as the sun makes it's arc across the sky. If colors change so easily, how then do we get an absolute handle on them? We do so, by measuring them under very controlled conditions and assigning numbers to them. The first such system was the CIE color system developed in the 1930s. Colors are read by colorimeters (color light meters) and plotted on a chromaticity diagram. This assignment of numbers to specific colors and plotting them on a chart is a **color model**.

What is a Color Profile?

Once a color model has been created to specify colors, only part of the job is done. That's because different systems use different models. For example, your monitor is based on a RGB color model and your color printer is based on a CMYK model. A **device color profile** is used to relate different color models such as these. Here's a simple table that shows how five basic colors can be related using tables. For example, when a red color on the screen is sent to the printer as the series of numbers 255,0,0; the printer uses the profile to see that it should assign the color 0, 100, 100,0.

	RGB Color Model			CMYK Color Model			
Color	R	G	B	C	M	Y	K
Red	255	0	0	0	100	100	0
Green	0	255	0	100	0	100	0
Blue	0	0	255	100	100	0	0
Black	0	0	0	0	0	0	100
White	255	255	255	0	0	0	0

10.5 FINE ART PLATINUM PRINTER GOES DIGITAL

Featuring Tom Millea

TMillea@aol.com

<http://www.tommillea.com/>

If Ansel Adams and Edward Weston were alive today, one wonders if they would be exploring digital imaging. It's hard to say, but Ansel at least was not so rooted in the classic ways that he wasn't curious about new technologies. Not only was he scientifically oriented, over the years he became great friends with Edward Land and spent much time using Polaroid materials.

The Carmel, California area where both Weston and Adams lived has a long tradition in photography that continues to this day. Among the many fine photographers still working there is Tom Millea, a direct descent of the great photographers who came before him. Like them, Tom makes his living from the sale of his prints. His photographs are in private, corporate and museum collections in the United States and Europe. His "Yosemite Valley" portfolio was the first one ever published by The Ansel Adams Gallery, Best's Studio, Inc. in its ninety-two years of supporting photography.



Tree at Pt. Lobos (click to enlarge). Copyright [Tom Millea](#).

During his almost three decades in Carmel, Tom got to know Ansel quite well. Although Tom worked in Platinum photography and Ansel in silver, Ansel encouraged him and had a lasting impact on his life. As Tom has said "I am always surprised to see the number of people Ansel has affected and how long the effect has lasted. "

When Tom won the second Ruttenberg Fellowship from the [Friends of Photography](#), it was Ansel who presented him the prestigious award.



Tom Millea in his digital darkroom in the mountains above Carmel.

Using Computers

Although Tom is a classic photographer in every sense of the word, he is on the frontier exploring the use of computers and digital imaging in fine art photography. He feels that many photographers have not yet made the connection that it is possible and EASY to make beautiful

straight images using their desktop equipment. He's interested in sharing what he's learned to show others how beautiful photographs can be made using the computer and Photoshop in the most simple ways. He teaches privately and has repeatedly proved his contention that "I can teach someone the basics in one day. I can promise a student that he or she will make prints as beautiful as mine in one day. How's that for simple! I can promise beautiful print quality—I cannot promise good images."

"I learned a long time ago that the greatest images from the greatest artists are made with the simplest equipment—often under primitive conditions. From Alfred Stieglitz making prints in his bathtub to Edward Weston printing with a light bulb hanging from the ceiling. Even Ansel Adams had a VERY simple darkroom with a homemade enlarger. It is not the equipment, it is the person behind the equipment. I guess that is heresy for all the equipment makers out there, but that is a fact. (I have seen darkrooms all over this country of ours that could well be trendy restaurants as well as darkrooms. I am still waiting for a good photograph to come out of these places.)"



Victoria. Copyright [Tom Millea](#).

Here's what Tom has to say about integrating digital imaging into his platinum style.

I feel myself to be like most people out there. I do not have a great deal of money and there are no big corporations backing my work and giving me lots of equipment to use. Whatever work I do I must pay for myself, so out of necessity I must find ways of working that give me the results I expect with equipment I can afford. I have reduced the process to its simplest elements and allow my talent for image making to do the rest."



I have been photographing for thirty-five years, most of that time doing Platinum prints, a time consuming, deadly process, which uses hydrochloric acid and platinum salts along with other

image as beautiful but found none.

Iris Printing

In the late 1980s I saw the possibility of making prints with the computer and printing them in a process called Iris. I used this process, working with master printers, and the results were beautiful. Unfortunately, the prints were only stable for a few years. I was forced to back off. Collectors demand that prints last forever and then some. If the prints do not last, collectors will not buy them and I make no money to live. I kept at it, working with different people, until finally, just last year, the inks were made to be stable and the quality became even better.



Torso. Copyright [Tom Millea](#).

Finally it is possible to make a print which has the same lush tones as a platinum print. These new [Iris prints](#) are made on beautiful papers (such as Arches) and will last for an indefinite period of time. (150 years at least. That is the same amount of time photography has been around.)

I am what is known as a straight photographer. My images are not conceptual. That means I do not make things up in my head. I do not take pieces from many subjects and put them together to make new objects. Rather, I see something I wish to photograph and then make the photograph. The final print is a reflection of what I saw and the way I respond to what I saw in the real world.

Capturing Images

I go into the world with a traditional camera (Nikon S 90) and film (Scala, a B&W slide film) and make my photographs. Be it a portrait or a landscape or a figure study, I still use a traditional camera and film. But that is where the traditional ends.

Agfa makes a beautiful film called Scala. It is a B&W film which produces B&W slides. Polaroid also makes a B&W film called Polapan which you can process yourself with a small machine made by them. Both films produce excellent results. I use 35 mm film and camera for making platinum prints because it saves me a generation of negative making when I need a negative for the Platinum print. (Platinum prints are a contact printing process. The size of the negative is the size of the print. Using 35 mm means I must make a large negative in the darkroom to make a print big enough for people to enjoy.)



Sue. Copyright [Tom Millea](#).

The Digital Darkroom

So now I have a 35 mm slide. No negative to fool with, no contact sheets to look over, just a slide easily viewed. Once I find an image I wish to print I place it in my Polaroid 35 mm scanner. I crank up my Apple 8500 power Mac and import the slide into Photoshop. Very easy and very fast. Takes less than a minute. I have 208 Mb of ram which is more than most small photographs need, but I find it helps with the speed of doing tasks. Once in Photoshop I can then manipulate the image exactly as I would in the darkroom. Contrast, cropping, size, color, density, all the tasks one does in the darkroom.

Except I am able to look out of my window at the mountains which surround my house and I do not have to breath all the toxic fumes locked in some dismal room with a small red light!



Tom on the deck outside of his Carmel home.

I use the Apple 8.5 operating system on the computer which makes getting into and out of files very simple and easy. I also have an Apple 21 inch monitor which makes seeing the image a pleasure. I can see all the scratches and dust spots before I print the photograph which saves me a lot of money in paper, ink and time. I had to learn the importance of a good monitor the hard way.

With this equipment, I can concentrate on making the photograph, not on which buttons to push or where some program is stored.

Once I have the image looking the way I want it to look on the screen, I then make a print on my Epson Photo EX printer. I can easily make 11x14 inch prints on this machine. Most often I print using black ink only, so the prints last much longer. If I want a larger print, I send it to my Iris printer in NYC and have an Archival print made for shows and galleries.

It has taken ten years of work to come to this simple level. The process is now at a point where the average person can work and produce images as good or better than can be produced in a traditional darkroom. I can teach people to make beautiful prints in one day on the Mac. Now

photographers are able to concentrate on seeing the world and producing their images, rather than becoming buried in technical problems which cause a person to forget why they are making a photograph in the first place!

Reaching an Audience

There is more to this story. This is the part about how I save a huge amount of money and time.

In the past it was necessary for me to have a huge inventory of prints and to ship these prints to many collectors and galleries and museums. The prints were constantly in the mail or Fed-ex. The number of prints lost or damaged was considerable. Now, when someone wants to see the work that I do, I simply e-mail the photographs to them at no cost to me! I can put together whole shows and provide exact sequences over the net. I can have answers the same day and produce only the prints the gallery wants to use for any given show.

This saves thousands of dollars a month and a huge amount of time. I can make new images rather than slaving in the darkroom guessing what someone might like to see. I need only have about half the inventory I needed in the past which again saves me huge dollars. Consider that a platinum print might cost 100 to 1000 dollars to make and the amount of money saved is considerable.

Showing you photographs is a good example. Yesterday I sent off 30 images to a gallery on the East Coast. It cost me nothing.

Finding ways to show my photographs electronically has cut my costs in half. It allows me to make new images with money that was spent on production and mailings. As an Artist, I want to do new work not continuously make old photographs over and over. Now I can do it. This is very exciting to me. I can reach collectors all over the world by using the worldwide web to show my work. This has never been possible before. I can print whole books on the web for no cost and take orders from people who see it. In the next few years

I will save hundreds of thousands of dollars on book costs alone!!!

I can put together a new book any time I want and as many books as I feel like doing and publish them on the web. If the response is good then I might publish them in print. The possibilities are endless.

For Galleries and Museums, I simply write and e-mail with a new photograph or two and ask if they want to see more. If the answer is yes I send twenty by e-mail. I have my answer in a day or two and it costs no money. In the past, sending prints through the mail might cost me 75 or 100 dollars to pack and ship 20 prints plus the cost of the prints. The money adds up very fast. I am just delighted with the advantages of using the computer for making art.

My audience has increased tenfold and with the proper advertising there is no limit to the number of people who will see my work.

CHAPTER 11, DISPLAYING & SHARING IMAGES



Objectives

Introduction

Very few photographers put their photos in a box and slide it under the bed. Most of us want to share them with others. Until recently, only a lucky few were able to show images to a circle much bigger than friends and family. However, for good or bad, we can now share them with the world. There are a number of ways to do so. You can "broadcast" them to a large audience by placing them on the web where anyone can see them, or you can "narrow cast" them to specific individuals. For example;

- You can post them on your own Web site
- You can post them on one of the picture networks and leave them open to the public or protect them with a password
- You can send them as post cards
- You can send them by-email

Each of these methods has its own attractions and they really don't overlap a lot. It's possible you may use one or all of them at different times, depending on what you're trying to

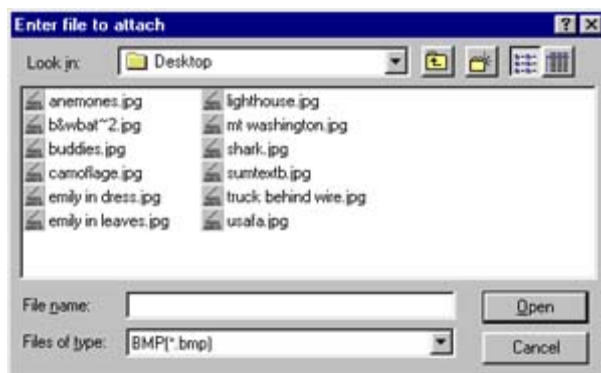
accomplish. Lets take a look at each of them in more detail.

11.1 E-MAILING IMAGES

What if you have an image, or other file, and want to send it to someone. Not too long ago, your only choices were to print it out and either post or fax it. The easiest and cheapest one now is to attach the image file to an e-mail message and send it to the recipient that way. E-mail has become so universal that it's a great way to distribute your photographs.

Attachments are files that are sent along with email messages. If email messages were paper memos, attachments would be files that you fastened to the memo with a paper clip. You can attach web pages, sound files, image files, and executable files.

All you have to do is create an e-mail message addressed to the person you want to send a picture to and attach the photo. Almost all e-mail program's have an Attach command somewhere on their menus. When you use this command, you have to enter the name of the photograph you want to attach and most programs will let you browse to find it on your system.



The Attach dialog box usually looks just like the standard Open dialog box so you can browse for the folder and image file you want to send.

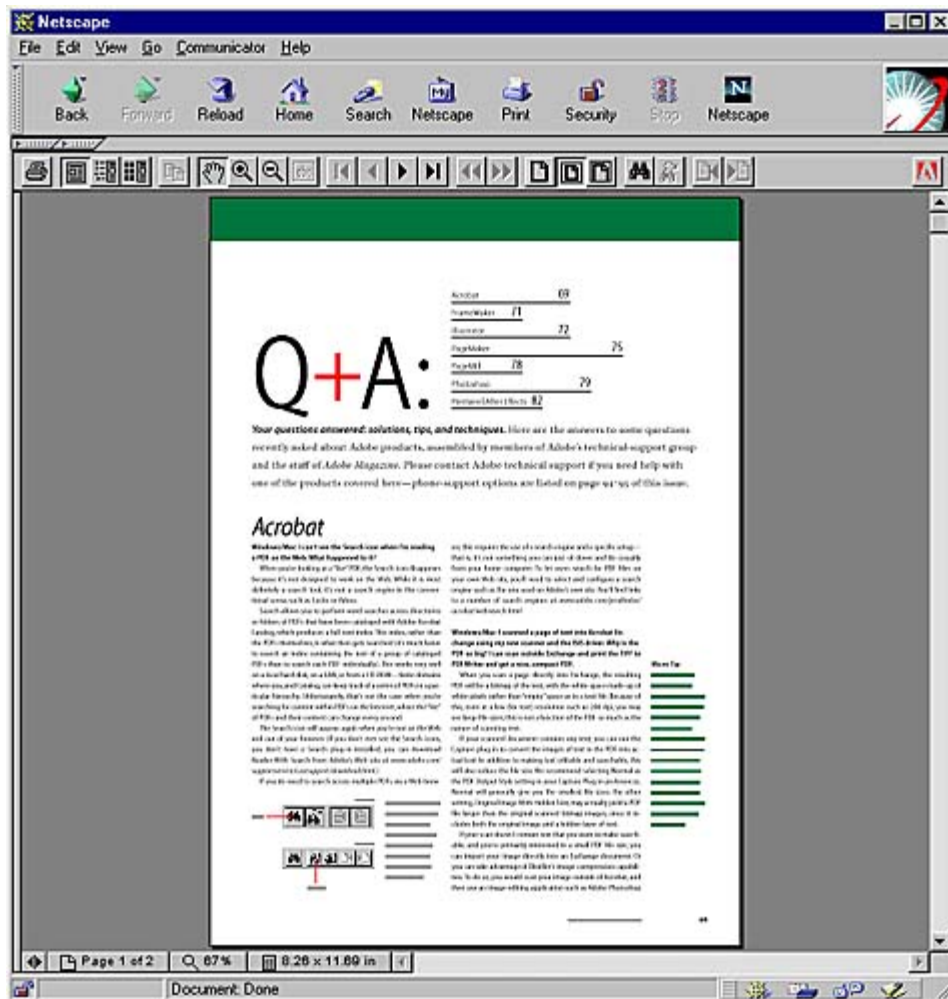
11.2 POSTING IMAGES ON THE WEB

When creating images for the Web, the most important thing is to keep the images small; maybe 20 Kilobytes or so. If one takes longer than a few seconds to load, the viewer has probably moved on. Here are some other things to consider that either improve the image or make it smaller.

- When editing an image, use the highest possible resolution and color depth. Be sure to save this file in the program's native format or a format such as BMP or TIF that uses lossless compression.
- Use your program's unsharp filter to sharpen the edges in the image and remove blurring that derived from the original photograph or scanning process. This filter identifies any adjacent pixels that have a specified difference in brightness and increases the contrast between these pixels by a specified amount.
- Reduce the image's resolution to 72 dpi and then resize it for screen display. The most common display today runs in 800 x 600 mode but some run higher and some run lower. The best compromise is a horizontal image about 600 pixels wide or a vertical image with between 400 and 500 pixels vertically.
- Save the image in the JPEG format with a low or medium quality level.

11.3 ADOBE PDF FILES

When you want to publish photographs and text on the Web and retain high quality formatting, you have to move beyond HTML. The most popular format now is Adobe's PDF (Portable Document Format). With the Adobe Acrobat authoring system, you create the document in a program such as Word, QuarkXPress, or PageMaker and then use a menu command to save it as an Adobe PDF file. Any user with an [Adobe Acrobat plug-in](#) for their browser can then open the document of their system and it looks exactly like the original.



With the Adobe Acrobat browser plug-in installed, you can view richly formatted PDF files.



11.4 MOUNTING AND FRAMING PRINTS

When you get a good print, you want to show it off. Mounting attaches the print to a heavy-weight piece of cardboard. This keeps the print positioned for viewing and protects it from creasing. Overmatting or matting a print involves cutting an opening the size of the print in a larger piece of board. An overmat keeps the surface of the print from touching the glass in a frame, which is desirable because under pressure the print may adhere to the surface of the glass.



Light Impressions carries both archival mat board and precut mats. Courtesy of [Light Impressions](#).

For both mounting and matting, the ideal material for valued prints is archival or museum quality, high-cellulose mount board because they are free of the acidity that may eventually discolor a print. For short-term display or less valuable prints, ordinary mounting boards are less expensive and widely available in art and framing supply stores.

Attaching the print to the mount board may be done in several ways. Prints can also be slipped into photo corners which are then hidden when the print is overmatted. This method avoids having adhesives in direct contact with your photo and also makes it easy to remove it from the board. Another way to mount a print is using taped hinges. Ideally the tape should be acid-free linen tape available where good quality mount board is sold. With ink-jet prints avoid such procedures as dry mounting which used heat, and materials such as cellulose tape, masking tape, brown paper tape, or glues that are likely to discolor over time. Tapes and glues are archival only if they don't affect the print's color over time and are completely removable.

Frames come in a variety of styles. Clip frames are just four small clips and a piece of glass. Precut metal frames are sold in various lengths, 2 to a package, so you can assemble frames of almost any size and shape. There are also wood, metal, and all-plastic frames in fixed sizes.



Light Impressions sells very attractive wooden frames at reasonable prices. Courtesy of [Light Impressions](#).

When hanging prints, avoid places where direct sunlight hits them. You should also try to avoid other forms of bright light because the more light a print is exposed to, the faster it fades. If you can't avoid strong light, you can rotate your images.



Matthew Brady, best known for his company's Civil War photographs, had a huge photographic gallery at the corner of Broadway and Tenth Street, in New York in 1861. As you can tell from this engraving, mats and frames were very popular back then. Courtesy of the [Library of Congress](#).

11.5 COPYRIGHT AND PHOTOGRAPHY

In most countries around the world, it is recognized that writers, artists, programmers, sculptors, and entertainers have a right to their own work. Generally these rights are protected by copyright laws. For example, in the United States, they are protected in the U.S. Constitution (Article I, Section 8) where it 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 things in places like the Web that are interesting, 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 incorporate some of the text or photographs in one of your own reports, presentation, or Web sites. Now you are using the materials for other than your own personal use. This 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 OK 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."



*The U.S.
[Copyright Office.](http://lcweb.loc.gov/copyright/)
The one in your
country may be
different.*

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.

Fair Use

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

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, 18th-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. Two good sources of copyright information and [Kodak's](#) and the [United States Copyright Office](#).

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, whichever is shorter.
Works Originally Created Before January 1, 1978, But Not Published or Registered by That Date	The duration of copyright in these works will generally be computed in the same way as for works created on or after January 1, 1978: the life-plus-50 or 75/100-year terms will apply to them as well. The law provides that in no case will the term of copyright for works in this category expire before December 31, 2002, and for works published on or before December 31, 2002, the term of copyright will not expire before December 31, 2027.
Works Originally Created and Published or Registered Before January 1, 1978	Under the law in effect before 1978, copyright was secured either on the date a work was published or on the date of registration if the work was registered in unpublished form. In either case, the copyright endured for a first term of 28 years from the date it was secured. During the last (28th) year of the first term, the copyright was eligible for renewal. The current

	copyright law has extended the renewal term from 28 to 47 years for copyrights that were subsisting on January 1, 1978, making these works eligible for a total term of protection of 75 years.
--	---

Protecting your Work

Watermarks were first used in Europe to identify the guild that manufactured paper. They were like trademarks or signatures. Watermarks in paper are created by varying the paper's density. Normally invisible, a watermark image becomes visible as darker and lighter areas when the paper is held up to the light. Wire or relief sculptures are placed in the paper mold and when the paper slurry is drained of its water and dried the thinner areas created by the wire or sculpture show clearly when held up to the light. Watermarks are still used in quality stationary and have even been added to U.S. currency.



[Watermark on new \\$100 bill](#) shows Benjamin Franklin when you hold the bill up to the light.

Digital watermarks for photographs work differently than those used for paper. There are two basic kinds: visible and invisible.

Visible Watermarks

A visible watermark is a translucent image overlaid on the primary image. The watermark doesn't totally obscure the primary image, but it does identify the owner and prevents the image from being used without that identification attached.

Invisible Watermarks

An invisible watermark is embedded in an image and although it isn't visible, it can be displayed with the appropriate software. There are two basic types of invisible watermarks:

- A watermark can prove an image's authenticity if manipulating the image destroys the watermark. An intact watermark is proof that the image hasn't been altered or tampered with. Journalists and courts are among those interested in ensuring images haven't been doctored.
- A watermark that resists destruction can establish an image's ownership. For example, images posted on the Web can't be copied and used undetected.

Invisible watermarks, such as those developed by [Digimarc](#), are hidden in the image and can survive image cropping and file format changes. They are almost indestructible. However, with a reader, you can display them and learn who created the photograph and how to get in touch with them. This is like free advertising. If someone sees your image, and wants to contact you about reusing it, they can easily do so.

However that's not all. If someone takes one of your images and posts them on the Web, a search engine designed to look for watermarks can locate the images. This way, people can't use your images without your permission.

Artistscope

[Artistscope](#) offers a different approach to protecting your images. They prevent downloads and MouseSave actions by encrypting the image so that it may only be viewed from within an applet delegated to the designated and registered site. It comes complete with a desktop application for the encryption and extensive editing of all JPG and GIF files.

CHAPTER 12, SPECIAL PURPOSE PHOTOGRAPHY



12.1 MACRO PHOTOGRAPHY

One thing digital cameras are great for is photographing small objects—coins, jewelry, prints, maps, even insects—anything small enough to fit on a tabletop. You can put photos of your collectibles onto a Web page, sell them on an on-line auction, or make prints to file in a safe deposit box for insurance purposes. In close-up or tabletop photography, digital cameras have a huge advantage over traditional film cameras because you can review your results and make adjustments as you shoot. If a photo doesn't turn out as you'd hoped, just delete it and try something new. A film photographer has to wait to get the film back from the lab before they can make adjustments. By then, they have probably taken apart the tabletop setup or forgotten what it was they did. Take advantage of your instant feedback to experiment and learn.



Macro photographs can reveal stunning details of the world around you.

The guidelines that follow are just that—guidelines. Feel free to experiment and break the rules. Never let the fact that you don't have something like a light source stop you. Innovate and experiment. That's how great photographs are taken.



A rainstorm brought leaves down onto a skylight. A ladder and macro mode captured this backlit image.

Macro Lenses

When photographing small objects from coins to insects, your lens' minimum focusing distance determines how close you can get to the subject. The closer you can get to a subject, the larger it will be in the final image. A tiny coin surrounded by a large background isn't what you're trying to get. You're trying to get a large coin surrounded by a small background. For many pictures, just zooming your lens in on the subject will suffice. However, macro mode allows you to get a lot closer to the subject, making it much larger in the final image. If you can't get close enough to an object to fill the image area, you can always crop out the unwanted areas later. Just keep in mind that you don't have a lot of pixels to begin with and the more you crop, the smaller the image will become.

Keep in mind that when composing the image, you should use the LCD monitor, especially when closer than about 3 feet (90cm). If you don't, the object centered in the scene won't be centered in the photo.

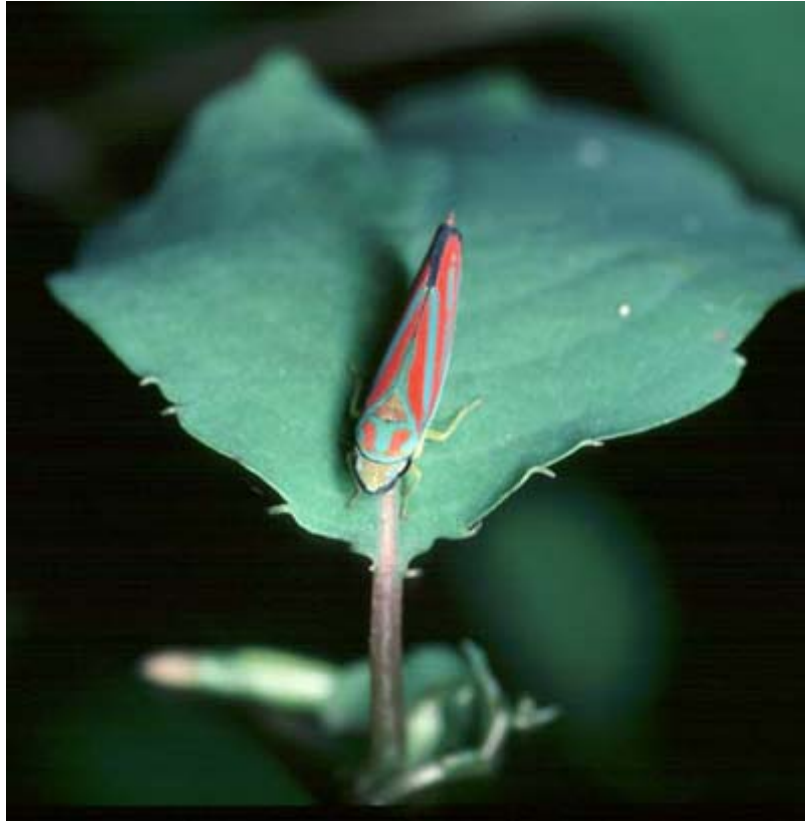


A monarch butterfly larva forming a chrysalis.

n



This small, but very colorful caterpillar was captured with a macro lens.



Here a leaf hopper is caught by a macro lens.

Focusing and Depth of Field

If you look at some close-up photographs, you will notice that very few of them appear to be completely sharp from foreground to background; in other words, the depth of field in a close-up tends to be shallow. The depth of field in an image depends on how small an aperture you use, how close you are to a subject, and how much the lens is zoomed. When you get the camera really close, don't expect much depth of field—maybe as little as a half-inch. It's best to arrange the objects so they all fall on the same plane. That way, if one's in focus, they all will be. Another thing to try with a zoom lens, is to use a wider angle of view. This will give you more depth of field if you don't also have to move the camera closer to the subject (doing so will offset the advantage of the wide-angle lens).

Also, when you focus, keep in mind that depth of field includes the plane you focus on plus an area in front of and behind that plane. You'll find that in close-ups half of the sharpest area will fall in front of the plane on which you focus and half behind it.

Shallow depth of field has its own benefits, so you don't necessarily have to think of it as a problem. An out-of-focus background can help isolate a small subject, making it stand out sharply.



In the left photo, a small aperture has given great depth of field. In the right photo, a large aperture has given a shallow depth of field. In both images, the camera was focused on the same building.

Tip: Use the LCD Monitor

When taking macro close-ups, especially at distances of less than 3 feet (90cm) use the LCD monitor to compose the image. If you don't, you won't be able to preview depth of field. Also, since the viewfinder is offset from the lens, the area seen in the viewfinder will differ from the area included in the image.

How To: Increasing depth of Field in Close-ups

- Increase the illumination of the subject to stop down the aperture.
- Don't get any closer to the subject than you have to.
- Focus on something in the middle of the scene (front to back) since in close-ups, depth of field is half in front and half behind the plane of critical focus.
- To increase depth of field, switch to aperture priority mode and select a small aperture such as f/11.

Exposures and Backgrounds

The exposure procedure for close-up and tabletop photography isn't a lot different from normal photography but you have the opportunity to control lighting. The biggest difficulty may arise from automatic exposure. Many close-up photographs are of small objects that don't entirely fill the viewfinder frame. Automatic exposure systems can be fooled if the brightness of the small object is different from the brightness of the larger background. The meter averages all of the light reflecting from the scene and may select an exposure that makes the main subject too light or too dark. In these cases, use exposure compensation to adjust for the background. If an image is too dark, increase the exposure. If the image is too light, decrease the exposure.

Some thought should be given to the background you use. It should be one that makes your subject jump out, and not overwhelm it. The safest background to use is a sheet of neutral gray poster board that can be formed into a curved "L" shape to give a nice smooth gradation of light behind the image. It's safe, because it reduces potential exposure problems and most

things show well against it. Other options include black or white backgrounds but they may cause some exposure problems unless you use exposure compensation. Finally there are colored backgrounds, but these should be selected to support and not clash with the colors in the subject.

The texture of the background is also a consideration. For example, black velvet has no reflections at all while black posterboard might show them.



A dark background sets off the small white sculpture.

Arranging Lighting

The lighting on small objects is just as important as it is for normal subjects. Objects need to be illuminated properly to bring out details and colors well. You can light a subject in several ways, depending on your objectives. A flat object needs to be illuminated evenly; an object with low relief, such as a coin needs to be cross-lit to bring out details; some objects might look better with the diffuse lighting provided by a light tent (see below). Electronic flash can freeze action and increase depth of field. Your options are varied, limited only by your willingness to experiment.

Flat copy such as posters, stamps, prints, or pages from books require soft, even light over their surface and the camera's image sensor must be exactly parallel to it to prevent "keystoning." Even then, most lenses will curve otherwise straight lines at the periphery of the image because they are not designed for copying and are not perfectly rectilinear. (This is called curvilinear distortion.) There are other lens aberrations that make it difficult to keep the entire image in focus at the same time. This is one reason to use a small aperture that increases depth of field and uses the center portion of the lens where aberrations are least likely to affect the image.



When photographing flat copy, you need even lighting.

Keep in mind that the color of the light you use to illuminate an object may affect the colors in the final image. Tungsten bulbs will give it an orange cast and fluorescent lights will give it a green cast. You'll have to experiment with this aspect using manual white balance settings (see page 46). In other cases, you may find that you like the artificial colors or you may be able to adjust them in your image editing program.

Using a Reflector to Lighten Shadows

When the light illuminating a small subject casts hard, dark shadows, you can lighten the shadows by arranging reflectors around the subject to bounce part of the light back onto the shadowed area. You can use almost any relatively large, flat reflective object, including cardboard, cloth, or aluminum foil (crumpling the foil to wrinkle it, then opening it out again works best). Position the reflector so that it points toward the shadowed side of the subject. As you adjust the angle of the reflector, you will be able to observe its effects on the shadows. Use a white or neutral-toned reflector so the color of the reflector doesn't add a color cast to the image.

Using a Light Tent

One way to bathe a subject in soft, even lighting—particularly useful for highly reflective subjects such as jewelry—is by using a simple light tent. The object is surrounded by a translucent material which is lit from the outside. If the subject is small enough, you can use a plastic gallon milk bottle with the bottom cut out and the top enlarged for the camera lens. When positioned over the subject and illuminated by a pair of floodlights, the light inside the bottle is diffused by the translucent sides of the bottle. The result is a very even lighting of the

subject.

Larger subjects require larger light tents. You can construct a wooden frame and cover it with cloth or plastic sheets. When illuminated from outside by two or more floodlights, the light within the tent will be diffuse and nondirectional.

Using Flash in Close-ups

There are two important reasons to use flash in tabletop photography. With flash, you can use smaller apertures for greater depth of field, and extremely short bursts of light at close distances prevent camera or subject movement from causing blur. Using electronic flash with predictable results takes a little effort and you may need to practice and experiment.

External Flash

Direct on-camera flash doesn't give a picture the feeling of texture and depth that you can get from side-lighting. If you use an external flash, you can position the flash to illuminate the subject from an angle for a better lighting effect. External flash units can be connected to the camera's connector for external flash or can be a slave unit that fires when it senses the on-camera flash firing.



Flash was used to freeze this small green stinkbug.

Flash in Close-ups

When using flash for macro close-up images the flash may not fully illuminate the subject because of its position. Be sure to take a test shot.

Ring Flash

A special kind of flash, also available as slave units, is the ring flash. These units fit around the lens and fire a circle of light on the subject. They are ideal for shadowless close-up

photography such as that used in medical, dental, and nature photography. Because ring flash is so flat (shadowless), some units allow you to fire just one side or the other so the flash casts shadows that show surface modeling in the subject.



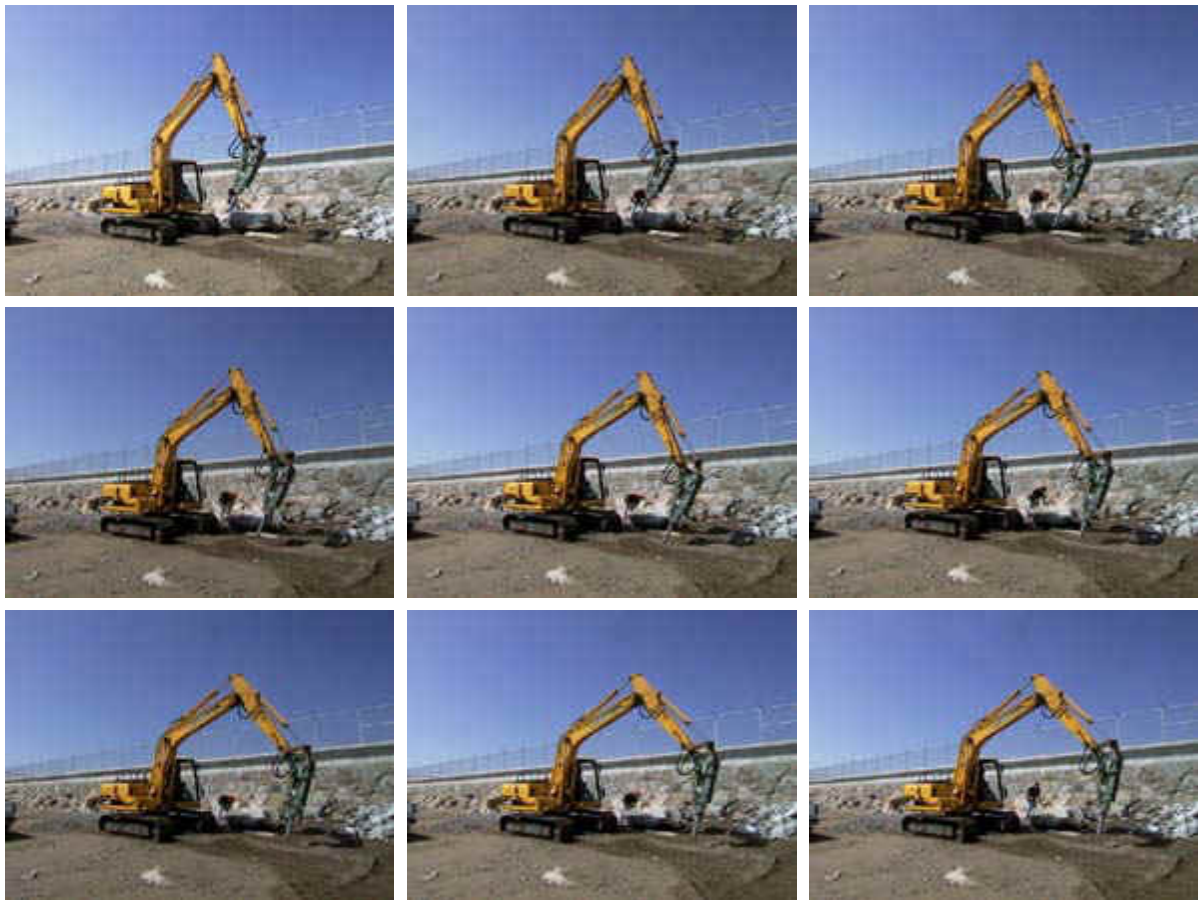
A ring flash used for close- up photography. Courtesy of [Digi-Slave](#).

12.2 CONTINUOUS PHOTOGRAPHY

With digital cameras, you normally take one photo at a time, but you're not limited to that way of shooting. You can also capture sequences of photos. In this continuous mode, you just hold down the shutter-release button and images are captured one after another. You can then choose the best image from the sequence or use all of them to create animations on your computer.

In most cases, the camera uses a smaller image size, such as 640 x 480 or smaller, to take sequences. This reduces the processing needed so you can take images at a faster rate.

When shooting in continuous mode, you'll take pictures more quickly if the light is brighter. You may get your best results in bright sunlight.



This sequence was taken in continuous mode on a bright sunny day. If you look closely, you'll see that the excavator's boom is moving out during the sequence.

Animated GIFs

There are programs that convert a series of images into an animated GIF. When posted on the Web, the images are quickly displayed one after the other like frames in a movie. One shareware program you can use is [GIF Construction Set](#).



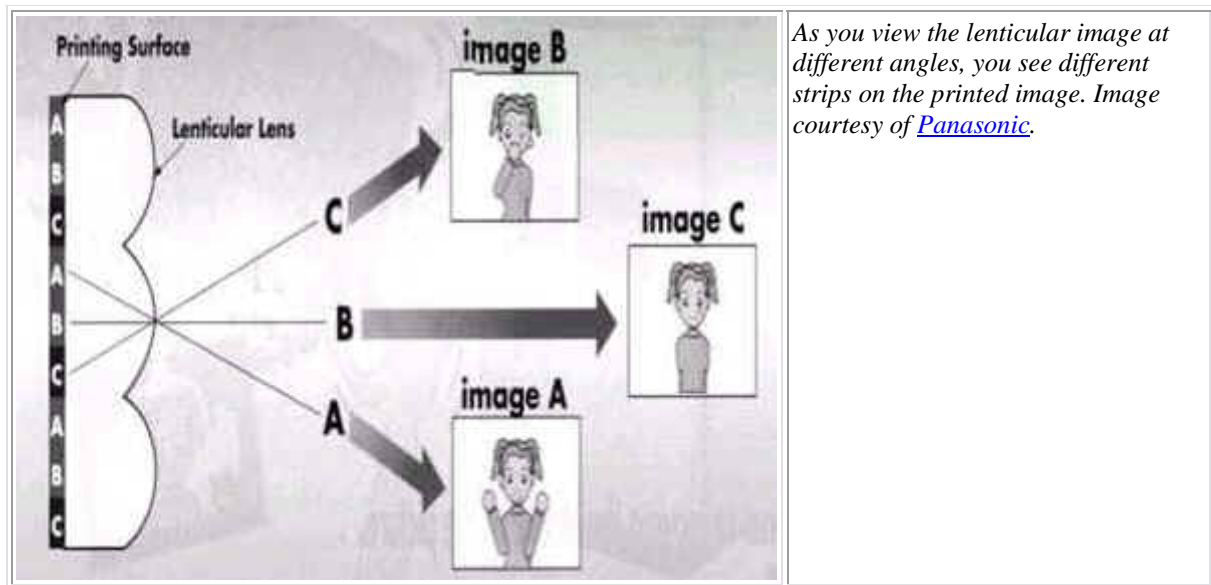
Lenticular Prints

For years there have been novelty cards that displays one image when held at one angle and another image when tilted to angle. The principle behind these cards, called lenticular photography, was first demonstrated by Gabriel Lippman in 1908. Lenticular images have come a long way since then and it's now possible to carry a short 1-second "video" in your pocket, or hang it on the wall. As you turn the image in your hand, or walk by a large one on the counter or wall, the image seems to come to life. Depending on how the underlying photographs are taken, lenticular images convey the illusion of 3D and/or video motion. You may have seen them on CD jewel cases, movie posters, Pokémon cards, and novelty items.

Recent advances are now bringing the creation of lenticular images to the desktop so you can make them yourself, or have them made for you at a reasonable price. Digital cameras should make this form of printing more popular than ever. For example, you can easily use your camera's sequence mode to capture the frames needed for a short video to be displayed on one of these cards. And they are no longer just cards. They can be found on mouse pads, counter displays, keyrings, or in frames on the wall.

A lenticular image has two components; a printed image and a lenticular lens screen through which the image is viewed.

- The printed image is two or more photographs (or other image types) interlaced in narrow strips. The number of images, or strips (called flips) is dependent on the size of the image. Smaller images can have more flips because the angle of view changes little from one side to the other. On larger images, when the angle of view varies a lot across the face of the image, the strips must be wider to prevent "ghosting" when you can see more than one strip. It's said that smaller images can contain 30 or more flips or frames, about 1 second of video.
- A lenticular lens screen is a sheet of plastic on which a series of cylindrical lens are molded in parallel rib-like rows. Each of the lenses, called a **lenticule**, has a focal length equal to the thickness of the clear plastic sheet on which it is molded. Each lenticule magnifies a very narrow strip of the image placed behind it. If you change your angle of view, the strip that is being magnified also changes. On a small card, each lenticule can show any one of 36 different strips depending on your angle of view.



Taking Images

The way images are taken determines what form the final lenticular image will take. Here are some of the possibilities:

- Flip images are any two images that flip back and forth as you turn the lenticular image.
- 3D images are created by shooting the same object or scene from different angles. One way to do this is to attach your camera to a slider bar mounted on a tripod. Between shots, you keep the camera facing the same way but move it along the slider from left to right. When the images are interlaced, you'll seem to "walk" around the object as you turn the card.



Flip! Slider lets you take multiple images of the same object or scene from different angles. Courtesy of [Flip Signs](#).

- Video effects are created by shooting a sequence of images from the same position. Alternatively, you can create a morphing effect and use those frames.

Software and Supplies

Kodak and other companies make high-end lenticular equipment used in commercial labs. However, [Tony Gelardi](#) and Dr. Stephen Fantone have jointly developed a desktop system of

software and lenses that makes it possible for anyone to create lenticular images on your desktop computer and inkjet printer. Their Starter 2 Software (\$69.95) can merge two images at 300 dpi resolution in a variety of sizes for use with frames, pins, magnets, and keychains.

Insight, Inc. offers a line of pre-preformatted premium papers for you to use with your desktop printer. Using Insight's Merge ready printer papers eliminates the need to cut or trim the printed image or images. Once you have the printed images, you can slip them into a number of lens designs.



Merge's 9"x10" display frame & special effects lens (MI-001) lets you slip in a lenticular photo created with their software. To change graphics just open the drawer and insert new graphic card under the special effects lens.

Printers

Lenticular images can be printed on almost any color printer and then mounted to a lens. However, the Panasonic P-M1000 Motion Printer prints directly onto the back of the lens. Used in conjunction with compatible software, the printer can combine up to six images on a business card sized (2" x 3") lenticular card and tilting the card gives the illusion of 3D motion. The P-M1000 is a dye sublimation printer and each takes about 2 minutes.



The Panasonic P-M1000 Motion Image Printer has a resolution of 300 by 600 dots per inch and a 16.7 million color gradation. Courtesy of [Panasonic](#).

12.3 PANORAMIC PHOTOGRAPHY

Most images on the Web are static, they just sit there like a picture hung on a digital wall. However, there are other photographs that you can pan and rotate. These images are products of immersive imaging techniques. There are two basic types; panoramas and objects.

Most photographs, even those taken with a wide-angle lens, show just a sliver of the overall scene. To take in the entire scene you have to spin around in a 360-degree circle, looking from a single point in space out to a surrounding environment. There are some cameras that will do just that. Others just take in slices that are wider than normal lenses without capturing the entire 360-degrees. Both types of cameras are expensive and there are now much less expensive digital ways to combine a series of photos into a seamless panorama.

There are a number of basic techniques used to capture panoramic images. The most popular include the following:

- Panoramas can be pieced together from a series of separate images. Once the images were mounted side-by-side on a cardboard backing. Now they are often digitally combined using stitching programs that seamlessly piece together a series of frames in panoramas covering 360 degrees or more.
- Cameras with a fixed lens and film take images just like a normal camera but on panoramic shaped frames of film. The 6x17 format is the most common way to do these professionally
- Swing lens cameras take images by swinging the lens during the exposure and painting an image on the film. These images cover less than 180 degrees of the scene.
- Rotational panorama cameras revolve on the tripod while the film moves in the opposite direction in the camera. These cameras can capture over 360 degrees.
- Strip scan panoramas, like those used to capture horses at the finish line paint the image of moving objects onto a piece of film moving at the same speed.

Early Panoramic Photographs

The first panoramas, taken in the 1840s, were made by taking a series of daguerreotype images that could then be framed or hung side-by-side. The same approach was later used with tintypes and paper prints.



An early panorama of Chicago before the fire. Courtesy of the [Library of Congress](#).

By the late twentieth century, motorized cameras were being made specifically for panoramic photography. In one type, the lens swung while the film remained stationary. In another type, the camera rotated on a special tripod to "paint" the image on a moving sheet of film. One of the most famous of such cameras, the Kodak Cirkut camera was patented in 1904. It used large format film, ranging in width from 5" to 16" could produce 360-degree photographs measuring up to 20 feet long.



An old Cirkut camera on its special tripod.

These cameras were frequently used to photograph groups, especially school classes. If you look closely at some of these photos, you'll see the same person appear twice, usually at the far left and far right ends of the picture. As the camera swings by the left end of the scene, someone can run quickly to the other end and freeze. They'll appear in both places. In the business, this is called a "pizza run."

Panoramas with Digital Cameras

Although panoramic photographs have been taken in sections and pasted together for years, it was the development of computer software that made seamless panoramas possible with a regular camera.

To create a seamless panorama with a digital camera, you begin by capturing a series of images around a single point of rotation, the optical center of the lens. Later, you stitch these views together with software.



Here are three overlapping images taken in sequence from left to right.



Here the three images have been stitched together into a single panorama.

TIPS: Basic Techniques

There are a few important ingredients in getting good panoramic images.

- Zooming the lens to a wide angle requires fewer pictures to cover the same view but make things appear smaller and more distant.
- When photographing a horizontal or vertical sequence, stand in the same position and rotate the camera.
- When photographing documents, center the camera over each section and keep it at the same height for each shot.
- Holding the camera vertically for horizontal panoramas gives you more height in the images but requires more images to cover the same horizontal area.
- The camera should be as level as possible as you take the pictures. In a 360-degree pan, the first and last images must "connect" and overlap.
- The images should overlap by 30-50% horizontally and not be out of vertical alignment by much more than 10%.
- Avoid placing subjects that move in overlapping areas and don't combine nearby objects in the same scene as distant ones or they will be distorted.
- Place a distinctive subject in each overlapping area to make it easy for the software to know how to combine the images.

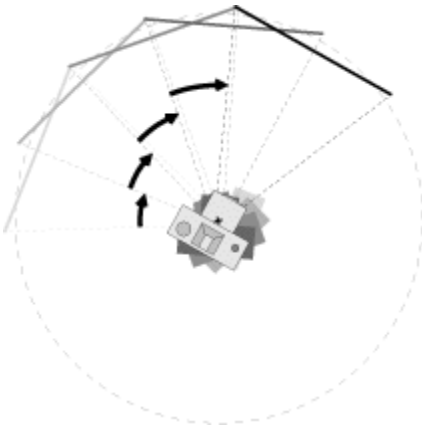
Capturing the Images

Although panoramic photographs have been taken in sections and pasted together for years, it was the development of computer software that made seem-less panoramas possible with a regular camera.



Long Beach, California, Bathing Beauty Parade, 1927. Courtesy of the Library of Congress.

To create a seamless panorama with a regular film or digital camera, you begin by capturing a series of images around a single point of rotation, the optical center of the lens. Later, you stitch these views together with software.



Individual, but overlapping pictures are captured around a point of rotation. Image courtesy of [Apple](#).

Hardware and Techniques

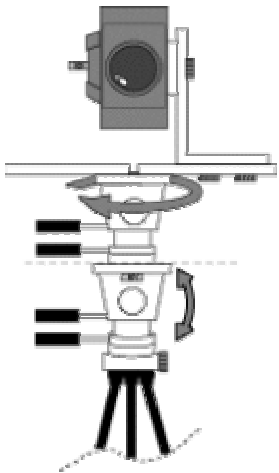
There are a few important ingredients in getting good panoramic images.

- You can use almost any kind of camera but you may have to be careful with the choice of lens.
- Wide angle lenses require fewer pictures to cover the same view but make things appear smaller and more distant.
- Rectilinear lens—those that make straight lines in the scene appear as straight lines in the image are required by many stitching programs. Most lenses are rectilinear, but "fish eye" type lenses aren't.
- The camera must be absolutely level as you rotate it.
- The images must be taken at specific increments and overlap by just the right amount; 25% on each side.

Leveling the Camera

The camera must be as level as possible as you rotate it in a circle so the photographs will line up when they are later stitched together. Some tripods have twin-axis bubble levels to guide you, but you can also use a small handheld level.

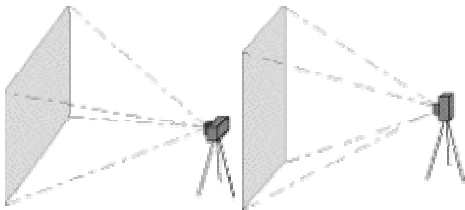
One of the problems with leveling a tripod is that the place where you mount the camera and the joint where the head rotates aren't necessarily aligned. This means that you can level the mounting area and it will become out of level as you rotate the head. You need to take some time to get it right. If you are a perfectionist, you can use two pan/tilt heads mounted together. You adjust the lower head to provide a level or tilted surface, and the upper head to rotate the camera.



Camera setup with two tripod heads. Image courtesy of [Apple](#).

Orientation

The camera's orientation depends on the scene that you are capturing. For most scenes the camera is mounted horizontally in landscape mode. This is easier to do and also requires fewer images to cover a scene. However, some scenes have vertical elements that require you to mount the camera vertically in portrait mode. This mode also gives you more ability to pan the image if you convert it to QuickTime VR or similar format.



Landscape orientation. Image courtesy of [Apple](#).

Portrait Orientation Image courtesy of [Apple](#).

To shoot with the camera in a vertical position, you'll need a bracket that keeps the axis of rotation centered on the optical center of the lens as you rotate it. These brackets hold the camera vertically and allow you to slide it sideways to position the lens over the center of the tripod.



The Peace River 3Sixty is an indexing panoramic mount compatible with most standard 35 mm SLR film and digital still cameras using a rectilinear wide angle lens for overlapping coverage of 360 degree scenes. It allows you to shift between increments of 12 & 18 and allows the camera to rotate more easily in one direction than the other to reduce the possibility of shooting images out of sequence. Image courtesy of [Peace River Studios](#).

Incrementing the Images

When you take a series of images, you have to be sure they cover the entire 360-degrees and overlap by 50%. You

guide you, but better ones come with detents so the camera snaps into place at the exact position.



The [Kaidan Landscape Bracket \(QPLB-1\)](#) uses detent discs with click-stops to let you easily rotate the camera the correct increments. Image courtesy of [Kaidan](#).

A wide angle lens will let you see a larger vertical field of view; however, it also gives the impression of "pushing" objects in the view farther away. The number of images you have to take depends on the focal length and angle of view of your lens. It also depends on the camera's orientation since you'll need more if the camera is mounted vertically.

To calculate your lens's angle of view, use the following formula:

$$2 * \arctan(X / (2 * f * (M + 1)))$$

- X= width, height, or diagonal of the film.
- f=focal length of the lens
- M=0 for a distant object

For example a 35mm frame is 24x36 mm, so with a 50 mm lens and a distant object (i.e. M virtually zero), the coverage is 27 degrees by 40 degrees, with a diagonal of 47 degrees.

Focal Length	Angle of View	Number of views	Increment between shots
24mm	84°	8.57	42%
35mm	63°	11.43	
50mm	46°	15.65	

Exposure

The software you use to stitch images together can even out the lighting in a scene but it helps if you give it good images to work with. When taking panoramas some cameras let you use autoexposure lock to ensure that exposure

first image in the series after turning on panoramic mode.

Try to avoid extremes in lighting. These occur on bright sunny days when there are bright highlights and dark shadows. The problem is compounded because you may have to shoot some of the pictures into the sun. If you can pick your time, pick a day when it's cloudy bright—overcast but with slight shadows on the ground. If the sun is out, shoot at midday to keep the lighting even. If you have to shoot at other times, position the camera so direct sunlight is blocked behind a tree or building when photographing in its direction. When shooting indoor panoramas, set up the camera to avoid shots of windows with direct sun shining through.

Panoramic Stitching Software

After you shoot a series of images for a panorama, you then have to digitize them if you didn't use a digital camera to capture them. Once in a digital format, you use software to stitch the digital images together into a seamless view. Here's how you do it with Roundabout Logic's Nodestar program.



You first acquire and arrange your source images in the "Frames" panel. Nodestar then calculates the frame overlap in the "Correlate" panel. You can fine-tune the results if necessary.

Nodestar automatically blends each frame to generate a seamless panoramic image in the "Panorama" panel.

You can output the finished panorama as a still image in any of the popular formats such as bmp or JPEG. You can also save panoramas in one of the supported interactive formats such as QuickTime VR. These formats let a user view the image on the screen, pan it, zoom it, and click hot spots embedded in it. For example, you can pan around a panorama of a room and click a doorway to display a panorama of an adjoining room.

The software you use depends to some extent on what output format you have chosen. For example, if you are planing to use an IPIX format, you have to also use their software to create the image and to view it. Other formats are more open. For example, a number of stitching programs will output interactive QuickTime VR panoramas (called "movies").

- Apple's [QuickTime VR Authoring Studio](#) for the PowerPC.
- PictureWorks' [Spin Panorama](#) transforms multiple still images into 360° QuickTime VR panoramic movies.
- Live Picture's PhotoVista stitches images taken with fisheye lenses of 16mm focal length or greater and images taken with wide-angle rectilinear lenses of 13mm focal length or greater. The resulting panoramas can then be viewed using the Live Picture Viewer, a browser plug-in, or the Live Picture Viewer—Java Edition. On the PhotoVista Macintosh version you can also save the finished images as QuickTime® VR format.
- Roundabout's [Nodestar](#) is a Macintosh tool for creating panoramic photographs using QuickTime VR standard.
- Unlike other panoramic imaging programs, [PanoramIX](#) does not require a fish-eye camera or software developer's kit to produce or view panoramic images.
- Orphan Technologies' [PanDC](#) (PowerPC only) rotates a digital or film-based camera to capture 360 degree panoramas or 160

degree stereoscopic panoramas. If you capture the image with a digital camera, it can correct the image for lens asphericity.



PanDC software (for MacOS PowerPC systems) uses a digital camera and a camera mount to make digital panoramic images. PanDC allows the automatic creation of partial or full 360° panoramic images, and up to 160° stereoscopic panoramic images. The resulting images are compatible for use as QuicktimeVR content. PanDC's stitching process is completely automatic and only takes about 6 minutes to stitch a full 360° panorama. Image courtesy of [Orphan Technologies](#)

- [VideoBrush Photographer](#) automatically stitches together a series of photographs into a single high-resolution image. To capture an entire scene, simply take a series of overlapping photos which "paint out" the scene. Your snapshots can cover a monument from top to bottom, a street fair from end to end, or a full 360-degree view of a family gathering-no need to back up or step out of the scene. Photographer will stitch these together into a single image, composing a wide-angle view out of the many separate photos.
- One interesting variant is [VideoBrush Panorama](#) that captures video sequences and turns them into panoramic images.

12.4 OBJECT PHOTOGRAPHY

Object photography is the opposite of panoramic photography. Instead of standing in one place and rotating to see a 360-degree view, object photography rotates an object for you so you can see all of its sides.



To create a rotational object, you start with a series of images showing the object from various angles. Images courtesy of [Peace River Studios](#).

To accurately capture the series of images, you use an *object rig*. This rig allows you to mount the object to be photographed on a turntable and positions the camera. As the object is then rotated a precise number of degrees between shots, the series of images is captured.



The Portable Object Maker is designed to capture views of objects up to 6 feet in diameter, at precise, user definable intervals. The captured images with the use of Apple's QuickTime VR Authoring Tools Suite, can be made into a navigable object movie. The mechanical functions of this machine are accomplished through the use of an indexable swing arm and an indexable turntable. Image courtesy of [Peace River Studios](#).

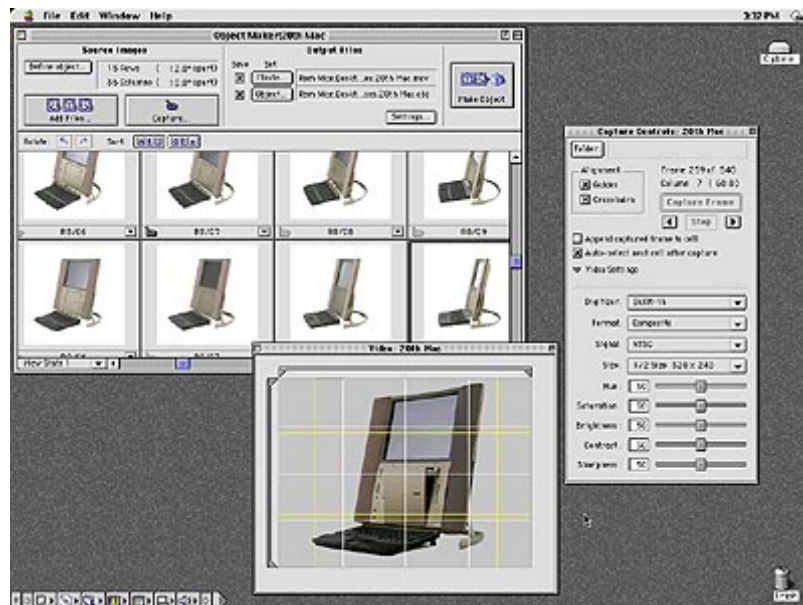


The Kaidan Meridan C60 Object Rig is used to mount the camera and object being photographed. Image courtesy of [Kaidan](#).



The object being photographed rests on a turntable that is then incremented between shots. Image courtesy of [Kaidan](#).

Once a series of images has been taken, you use a software program to stitch them together and then output the scene to a disk file. One of the most popular output formats is Apple's QuickTime VR.



Apple's new QuickTime VR Authoring Studio includes Object Maker which combines single frames and outputs a QuickTime VR Object Movie. it works with a variety of turntable and gantry systems to capture video images (or digital, or film-based still images) frame by frame. Image courtesy of [Apple](http://apple.com).

12.5 INTERACTIVE PLAYBACK SOFTWARE

You can post static panoramic images on the Web in the usual JPEG format. However, if you want to add interactivity to them, you need to choose an interactive format to save them in. The great thing about panoramas, especially 360-degree views is that you can pan and zoom them. From a central observation point, called a node, a viewer can look in any direction and may zoom into or out from a particular view by changing the zoom angle of their view.

Panoramic viewing is similar to, but different from VRML. In a VRML environment, you can freely move your viewpoint anywhere in the scene, but the motion is often jerky. Panoramic viewing positions your viewpoint in one spot in relation to the image and you view the scene from only that vantage point. The advantage is that your movement of the image is very smooth and the view is very realistic.

Unfortunately, there is more than one format to use for interactive panoramas and viewers aren't compatible. If you select QTVR panoramas, users without that software on the system can't view the image.

In addition to panning and zooming, panoramas can also have hot spots that link the panorama to other panoramas or objects. For example, a user can pan around a 360-degree view of a room and click doors to move to panoramas of those room.

- The [Live Picture Viewer](#) is a small Java applet that displays PhotoVista images on the Web without a plug-in. It downloads with the first picture selected and resides on the system for other images.
- IPIX images can be viewed on the Web with an [IPIX plug-in](#) for your browser. They can be viewed off-line with a separate viewer.
- AlphaWorks (IBM) PanoramIX is a [Web browser plug-in](#) panoramic viewer that allows user to view virtual panoramic scenes. With PanoramIX, users can interactively explore panoramic images compiled from photographs, rendered images-even scanned hand-drawn sketches.

QuickTime VR

Once created, QTVR scenes are saved as a self-contained file. They can play back as stand alone files on either a Macintosh or Windows machine using the MoviePlayer application (provided, of course, that the platform has both the QuickTime and QuickTime VR extensions installed), or directly on-line in a World Wide Web page if using the correct [QuickTime and QuickTime VR plug-ins](#) with an Internet browser.

If, however, the scene includes panoramas or objects which contain links to other types of media, such as graphics, text, videos, or sounds, then the scene must be incorporated into a multimedia authoring environment, such as [Apple Media Tool](#), [Macromedia Director](#), or [mFactory's mTropolis](#), to manipulate these other media components.

When you view a QTVR scene on the Web, here are the ways you navigate it.

To:	Macintosh:	Windows:
Pan the image	Click and drag	Click and drag
Zoom in (panoramas)	Press Option	Press Shift
Zoom out (panoramas)	Press Control	Press Control
Jump to another location (panoramas)	Click a jump spot	Click a jump spot
Save a panorama or object embedded in a web page	Press and hold the mouse button; from the popup choose Save	Click the image and select Save from the pop-up menu
Save a panorama or object displayed in a standalone window	Pull down the File menu, and click Save	Pull down the File menu, and click Save As...

12.6 IPIX: PHOTOGRAPHY IN THE ROUND

Featuring Bill Swersey

Bswersey@aol.com

<http://www.swersey.com/>

Imagine being inside a photographic globe where no matter which direction you turn or where look, you see that part of the scene just as if you were in the real world. This is what IPIX™ immersive imagery is all about. Although other panoramic technologies such as QuickTime VR show 360-degree horizontal views, none show an entire sphere. They display images like balls with the tops and bottoms removed (picture a globe sliced through at the Arctic and Antarctic Circles). You can't look straight up, or straight down as you can with a 360° by 360° IPIX image.










Experiencing the IPIX Image

When viewing an IPIX image, you are positioned inside the sphere and can spin it in any direction using a mouse or other input device. Navigating one of these images gives you the feeling that you are turning around, looking up and down, or moving toward and away from parts of the scene.

IPIX images can have defined sections linked to other files. For example, a doorway in one IPIX image can be linked in this way to another IPIX showing an adjoining room. When the viewer double-clicks the doorway he or she "moves" into the next room. With a series of images strung together like this, you can take a virtual tour of a building.

Images can be linked to a variety of file types and as you move the mouse pointer around an IPIX scene, its shape changes when it passes over a hidden link. The shape it takes indicates the kind of file to which the link will take you if you double-click it. This table shows some Here are some of the shapes it takes when using the IPIX viewer. It takes other shapes when viewing a Java IPIX image.

Mouse Pointer Shapes	Descriptions
	Appears when you point to an IPIX image. To move inside the image, hold down the left mouse button and drag the hand in the direction you want to move. The hand's position determines the image's rotation speed. The closer it is to the edge of the image, the faster the image moves.
	Appears when you point slightly above the center of the image. Hold down the mouse button to zoom in.
	Appears when you point slightly below the center of the image. Hold down the mouse button to zoom in.
	Appears when you point to a link to another IPIX image. Double-click to display that image
	Appears when you point to an audio link. Double-click to play the narration or music.
	Appears when you point to an area programmed for automatic action and independent movement. (need to research this).
	Appears when you point to a link to another URL on the Web. Double-click to visit the page it's linked to.

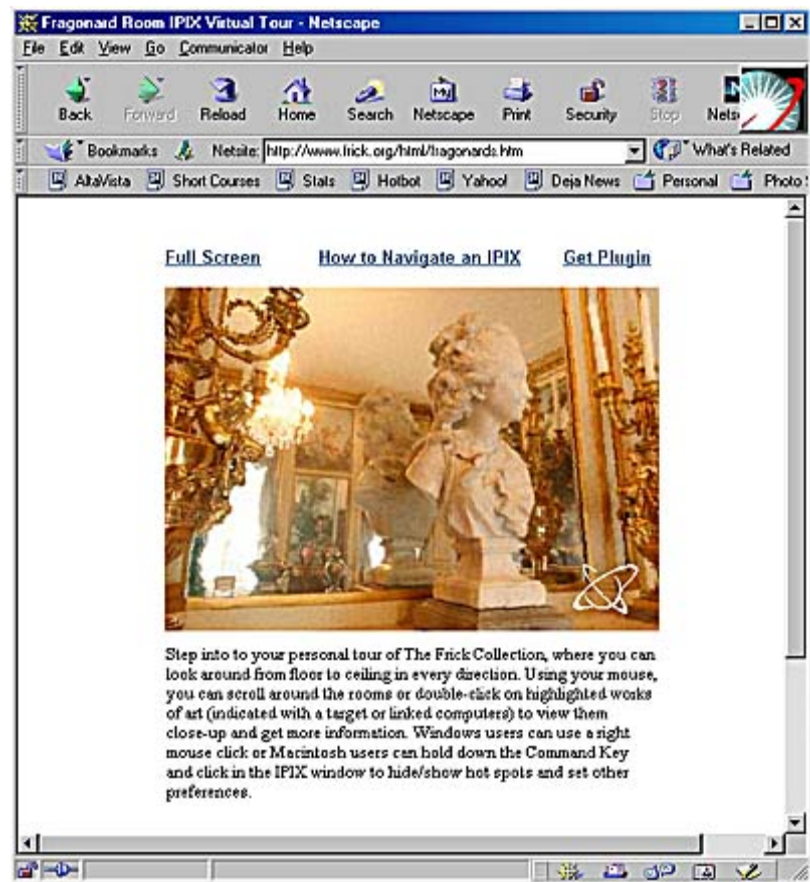
IPIX Applications

IPIX images appeal to anyone who wants to show three-dimensional spaces. A popular application is photo-realistic virtual walkthroughs of museums, homes offered for sale, resort or hotel facilities, cruise ships, and even sports stadiums. A person viewing the image can spin around to see all parts of a room from wall to wall and floor to ceiling or click a doorway to move to the next room. Even car makers have used IPIX to give prospective buyers an interactive view of their car interiors. One promising application, called OmniScope™, allows surgeons to see inside the body during non-invasive surgeries.

- Real estate agents use it to showcase properties
- Insurance adjusters document accidents or property damage
- Journalists capture locations or events
- Educators and trainers explore places, events, or products
- Marketers present product features and benefits
- Publishers illustrate Web publications and CD-ROM titles

- Media companies use it in interactive games
- Travel services showcase properties, cruise ships, and locales

*Bill Swersey
photographed the [Frick Museum](#)
for a virtual tour
posted on the Web.
Visitors to the Web site
can actually tour the
museum on-line.*



Creating IPIX Images

You create an IPIX image by stitching together two photographs called "hemispheres." To imagine this, picture a globe sliced in two at the equator. When "stitched" together, the two parts form a complete sphere.

Shooting the Scene

To capture the two hemisphere images, you use a film or digital camera equipped with an 8mm fisheye lens that can capture a 183-degree image. You place the camera on an IPIX rotator-tripod in the middle of any environment. Take the first picture, then rotate camera to the opposite 180 degrees position and take the second.

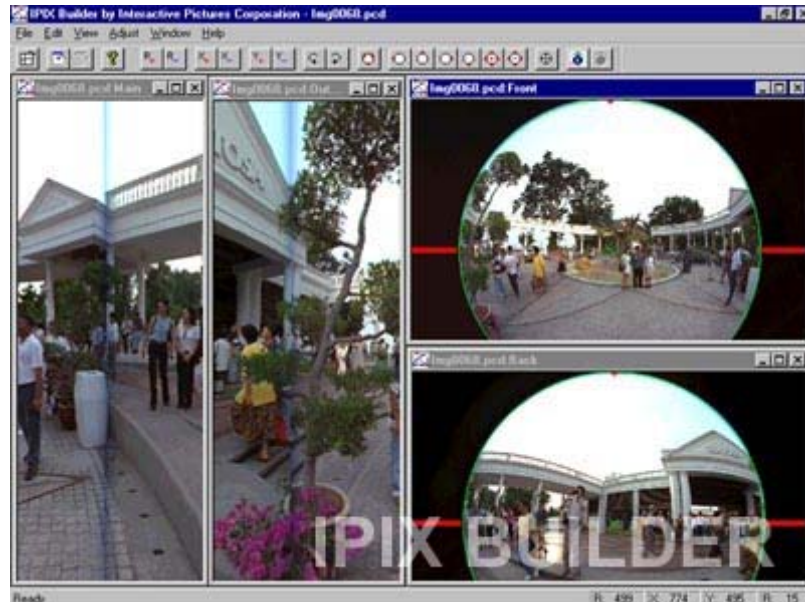
*Nikon has fisheye lens for
both their film and digital
cameras.*



Stitching the image together

To create the final IPIX image, you have to stitch the two hemispheres together. If they were taken on film, they'll have to be scanned because the software uses digital JPEG images. To stitch them into a seamless sphere, you use the IPIX Wizard or more powerful IPIX Multimedia Builder.

The IPIX Builder is used to stitch the two hemispheres together. The software also keeps track of your usage so you know when it's time to buy more keys.



Sharing IPIX Images

IPIX images can be distributed on the Web, on CDs, or by e-mail.

Browser plug-in

To immerse yourself in most IPIX images, you must first install the free IPIX Viewer Plug-in, software that gives your Web browser the capability to view IPIX images on Web pages.

Java versions

If you haven't installed the plug-in you can still view Java IPIX images with any browser that supports Java. Java versions of IPIX images must be especially created by the developer and the images are smaller than those viewed using the plug-in.

E-Mail

You can e-mail IPIX images by attaching them as files to your e-mail messages. The image has a self-contained player so the recipient can view it on his or her computer.

Types of IPIX Images

When IPIX Multimedia Builder is used to create an IPIX image, the final image can be saved

in one of four formats: Java, Quick View, Standard, and Broadband/CD-ROM. When built with the IPIX WIZARD, you can create all but the Broadband/CD-ROM versions.

The file sizes are determined by choosing more or less image compression and vary slightly due to the differences in initial quality and quantity of image data.

IPIX File Type	Size	Description
Java	30K-50K	Can be viewed on any up-to-date browser without a plug-in required.
Quick View	30K-90K	Ideal for very fast downloads and industrial/mass production purposes.
Standard IPIX Image	180K-280K	Compromise offering fairly short download times and fairly high quality resolution.
Broadband/CD-ROM	450K-2MB	The largest file size but the highest resolution and best detail.

The IPIX Business Model

Internet related businesses or technology such as IPIX have rapidly changing business models. At the moment, IPIX sells hardware used to take images and "keys" that allow you to use their software to stitch images together. Each key costs money and is good for one image.

Interactive Pictures Corporation, the IPIX developer, plans to apply this technology in the consumer photography market and as digital television becomes more pervasive, into the development of tools needed to create steerable video. This technology, also called V-360, uses two fisheye lenses to capture two video hemispheres which are stitched together and corrected for regular viewing in real time to let you choose where to look while viewing. You can interact with the image by navigating with your computer mouse.

Student Activities

Visit a number of sites featuring IPIX images and navigate them. As you do so, try to determine what makes some more appealing to you than others. Notice particularly what effects things such as this have:

- Objects placed prominently in the foreground
- Interesting objects attract your eye to the edge of the frame enticing you to pan
- Interesting objects above and below the normal viewing area

12.7 STERO PHOTOGRAPHY

Photographs are great at rendering the details in a scene but don't readily convey the impression of depth. Everything is rendered on a flat plane. Ever since photography was invented, people have been trying to correct this. There have been hundreds, if not thousands, of stereo patents filed and demonstration devices built. Sir Charles Wheatstone discovered the principles of stereoscopic vision in 1838, a year before photography was invented. 3-D or stereoscopic imagery uses two images of the same scene taken from slightly different viewpoints. Using one of many viewing technologies, the images are combined in your mind producing a third dimension—depth. 3D effects arise from the fact that each of your eyes sees from a slightly different perspective. To demonstrate this, hold your finger about a foot from your nose and close one eye, then reopen it and close the other. Your finger will appear to jump from side to side. This difference is due to parallax.



Stereo images displayed on the computer screen can great an illusion of depth. Image courtesy of [StereoGraphics](#).

The First Stereo Photographs

As soon as Henry Fox Talbot's and Daguerre's photographic processes were introduced in 1839, people started making stereo views. In many respects, the results were as good as those we get today. The problem was that the process of making the photos was expensive and there weren't any special or widely available viewers.



Daguerreotype stereo pair courtesy [Library of Congress](#).

The big breakthrough came in the 1850s with less expensive albumen prints and viewers—the

first invented by David Brewster, and a later and less expensive one by Oliver Wendall Holmes. Views of foreign places, and other scenes of all kinds, became the rage in Victorian homes and millions were sold. You can easily find some of these views in almost any antique shop although some are very expensive and they are fast disappearing as collectors gather them up. These mass-produced stereo cards have two prints mounted side-by-side on a piece of cardboard. They are inserted into a holder on the viewer and you view them through an eyepiece to see them in 3D.



A Thomas Houseworth stereo of Yosemite.



A Holmes stereo viewer comes in a do-it-yourself kit. Images courtesy of [Reel 3-D](#).

***IMAGE NEEDED** 3D movies were a big, but temporary hit, in the 1950s
(<http://albertareport.com/24arcopy/24a32cpy/2432ar01.htm>)

Taking Stereo Images

Almost all-stereo images start with a pair of photographs taken a few inches apart. The effect is to duplicate the spacing of our eyes that gives us stereo vision. Although it's possible to take a pair of stereo images with a single camera and lens, it's not the easiest way and the results are somewhat unpredictable. It's important that the lenses be the same focal length, exactly

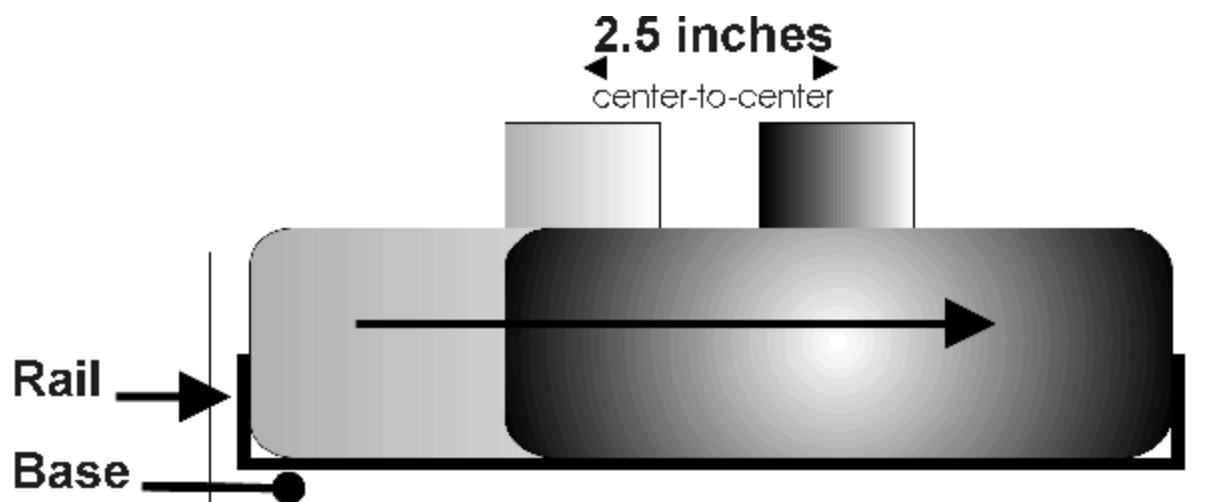
parallel, and offset by just the right amount—called the stereo base distance. For this reason, special cameras are usually used.



The Argus 3D Stereo Camera uses 35mm film. It has 2 matched 28mm lenses, 2 apertures (daylight and flash), and 1 shutter speed so everything is in focus from 2 1/2 feet to infinity. It also has a built-in pop-up flash. Image courtesy of [Reel 3-D](#).

If you don't have a special camera, you can experiment using the one you do have. (Adapted from [3D-Web](#).)

1. Create a guide that helps you move the camera 2.5" between shots and also keep the lens aligned so it's parallel. Just take a flat board and put a small wooden rail on it. When you slide the camera along the rail from flush-left to flush right, the lens moves exactly 2.5 inches. You can even add hardware to mount the base to your tripod.



2. Select a scene where nothing is moving—not even clouds or leaves in the wind. Be sure to include something in the foreground to give you a stereo effect. (A shot of distant mountains won't have any.) Generally, a 35mm camera with a 35mm lens can handle a depth range from 2 meters (7 feet) to infinity. Photographs taken that only include objects in this depth range will view perfectly well in any viewing device. Here are some guidelines for other scenes:

- If a foreground object is as close as 5 feet, objects more than 20 feet away must be excluded.
- If a foreground object is as close as 3 feet, objects more than ten feet away must be excluded.

3. Use a level to keep the camera level between shots. 4. Set the camera to a small f-stop for maximum depth-of-field. 5. Use the same exposure for both pictures. An alternative approach is to buy two disposable cameras and tape them together. You might want to tape them to a board or tripod so they don't move or learn how to press both shutter releases together.

IMAGE NEEDED

Stereoscopic Photography (<http://www.rpm.or.jp/home/h-kouno/3dphoto.htm>)

The problem with most stereo cameras is that they are based on old technology. There really isn't a high-quality modern 3D camera at a reasonable price. There are small firms that couple cameras together so you can take stereo images using modern equipment with autoexposure, auto focus, and so on. It's possible to couple two digital cameras in this same way. This eliminates the need to get film scanned to display it on the Web.



David Grenewetzki rigged two Kodak DC20 cameras to produce digital stereo pairs. Believe it or not he does this from remote control airplanes. There are lots more details on his Web site. Courtesy of [David Grenewetzki](#)



The Reel 3-D twin camera bar lets you mount two 35mm cameras side by side. The rig can then be tripod mounted or handheld. Image courtesy of [Reel 3-D](#).

Viewing Stereo Images

There are several methods that can be used to create stereoscopic images for viewing on a PC or web page. The most common images are:

- Cross-eye view images
- Parallel view images
- Anaglyph images
- Page flipped images viewed with shutter glasses
- Line alternate images viewed with shutter glasses and head mounted displays
- Squished Side by Side images viewed on lenticular displays
- Polarized images viewed with polarized glasses

Stereo Pairs

Stereo pairs can be easily viewed with a stereoscope or other viewer. But with practice, you can also view them unaided by such devices. All you have to do is look at them in the right way. When you finally see the depth information you have "fused" the images. When practicing these unaided techniques, take a break if you experience eye fatigue or discomfort. Keep in mind that not everyone can do these techniques.

- A pair of images designed for cross-eye viewing is arranged side-by-side with the image for the left eye on the right, and the one for the right eye on the left. To view them in 3D, you stare at them with your eyes crossed and this takes some practice. To begin, hold your head level and stare at a point between the two images and slowly cross your eyes. The images should merge so a third image appears in the middle in 3D. The original images will still be seen on either side, so ignore them and concentrate on the middle one.



You should see the solid circle floating above the outline circle. If the solid circle is below the outline circle, you have used the parallel free-vision fusion technique.

If you can't get the effect, hold your index finger half way between your eyes and the computer screen so both images are still visible. While staring at your fingertip, slowly bring it closer and farther from the screen. At some point, the images should merge into a single 3D image.

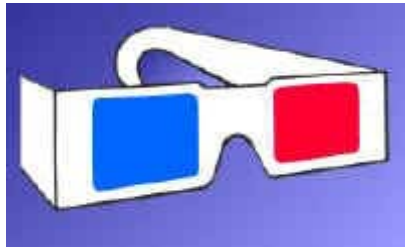
- A pair of images designed for parallel viewing (also called relaxed viewing or free viewing) is also arranged side-by-side. However, the image for the left eye is on the left, and the one for the right eye is on the right. To view the images, place your face close to the screen and then slowly back away while staring "through" the images to an imaginary point past them and behind the screen. When there appear to be three images, concentrate on the middle one until it becomes 3D. If you first see four images, concentrate harder on the imaginary point behind the screen until they become three images. It may help if you rotate your head slightly to the right or left while keeping it level.



If you have trouble bringing stereo prints into view, you can use a modern print viewer. There are lots of variations to choose from. Image courtesy of [Reel 3-D](#).

Anaglyph Images

Du Hauron, a French scientist patented the anaglyph method of stereoscopic photography in 1891. Anaglyphs, like other technologies, use a pair of images taken from slightly different vantage points. These two images are then color corrected and superimposed slightly out of register so one image is offset slightly from the other. When viewed through a pair of glasses with different colored lenses, the image appears in 3D. The glasses are usually red and blue, but they can also be other combinations depending on how the image was coded and the color of the glasses used to view them. Normally the red lens covers the left eye and the blue or green lens the right eye, but this can vary.



*Here are the familiar and low-cost red & blue anaglyph glasses.
Image courtesy of [Reel 3-D](#).*

In most cases the original images are converted to grayscale images which are then coded with red and blue colors that are balanced with the red/blue glasses. These are sometimes called "pure anaglyphs." Some images can be displayed in full color but most won't work very well.



*The Mars Pathfinder site even offers 3D movies of the rover exploring the surface of the planet.
http://mars.sgi.com/vrml/qtvr_stereo.html*

Shutter Glasses

An increasingly popular way to view 3D images on the screen is using shutter glasses. These glasses have high-speed electronic shutters that open and close in sync with the images on the monitor. Liquid Crystals are used for the shutters because an electronic signal can make the crystal turn instantly from transparent to opaque.

- When the left image is on the screen the left shutter is open and the right shutter is closed which allows the image to be viewed by your left eye only.
- When the right image is on the screen the right shutter is open and the left shutter is closed.

If this process happens fast enough, your brain thinks it is seeing a true stereoscopic image. If this shuttering speed is not fast enough, you can still see a stereoscopic image, but you may also see some flickering.



CrystalEyes shutter glasses use a wireless connection and deliver high-resolution stereoscopic 3D images. Many common software applications used in mechanical CAD, molecular modeling, GIS/mapping and medical imaging support StereoGraphics' CrystalEyes on all major UNIX platforms and Windows NT workstations. Image courtesy of [StereoGraphics](#).

Shutter glasses connect to your video card, parallel port or serial port with wires or with a wireless infrared transmitter. There are three approaches to rapidly alternating the displayed images while coordinating the shuttering of the LCS glasses. All display images in high-resolution and full-color.

- Page flipping rapidly switches the monitor between the right and left images. Special purpose video boards that support high-speed page flipping are available. These video adapters quickly alternate between frame buffers that each contains an entire image. The problem with this approach is that you may experience some flicker.
- Sync-doubling, used by a company called Neotek, displays the left image on the top half of the display and the right image on the bottom half. But you don't see them this way because a hardware device inserts an extra vertical-sync, or "new frame" signal after the computer has displayed the top half. The result is that you see an image that looks like it is page-flipped. In addition, the extra synch signal has the effect of doubling the refresh rate so each eye sees a normal frame rate.
- Line alternate images use a monitor's or head mounted display's ability to interlace images. Interlacing was used on early computers (and TVs) to create images while using little bandwidth. The screen was divided into scan lines. The image was then painted on it using first the odd lines. The scanning beam then returned to the top of the screen and filled in the even lines. When stereoscopic images are interlaced, the odd and even scan lines are used to display the left and right images. On the first pass, the image for one eye is displayed on odd lines. On the next pass, the second image is displayed on even lines. Many video cards have a built-in interlaced video mode that supports this technology.

Because computer display manufacturers dropped interlace mode in the 1980's, these devices require special 'device drivers' supplied by the LCD glasses supplier. There is also a drawback in that each left or right eye view is only made up of either the odd or even lines. This results in only half of the screen being used for each image and a 50% decrease in brightness.



StereoGraphics SimulEyes are lower-cost shutter glasses designed for viewing 3D multimedia and games. Image courtesy of [StereoGraphics](#)

Autostereo Images

The problem with most 3D viewing systems is that they require some form of eyewear.

right and left images into the correct eye. These autostereoscopic displays are expensive and display the images in a format that is squashed side-by-side. One big problem with these systems is that you can only view the images from a specific angle. The 3D image isn't seen if you are not positioned correctly.

Pulfrich Images

Strange as it may sound, if video is shot with the camera moving to the left or right, or if an object is spinning, it can be viewed in 3D. To do so, you cover one eye with a dark filter and leave the other eye uncovered. This effect, known as the Pulfrich effect was used for an episode of "3rd Rock from the Sun" in May of 1997. You can purchase a copy of this episode at www.3rdrock.com and view it with one lens of a pair of sunglasses held over your right eye.

Polarized Images

A final way to display images pairs is to display them on the screen one after the other with different polarizations. The first image is displayed with vertical polarization and the second with horizontal. When wearing a pair of glasses with matching polarizations, each eye only sees the image that matches its polarization.

- There are LCD panels that fit over a monitor and polarize the view in sync with the frame rate and allow the use of standard polarized glasses.
- If your system (monitor or presentation panel) has an Active Matrix LCD display, a Vrex micropolarizing filter polarizes every other pixel row into a left and right view. A group can view the displayed or projected image with standard polarized glasses.



Similar in appearance to an anti-glare screen mounted on the front of a computer monitor, the ZScreen enables on-screen images to be displayed with realistic depth, making objects appear to have presence in the user's physical environment. This allows scientific and technical professionals to better see and understand complex interactions between a wide variety of 3D elements, from molecules containing thousands of atoms, to the design and layout of an automobile's drivetrain and suspension. Stereographics ZScreen. Image courtesy of [StereoGraphics](http://StereoGraphics.com).

Web 3D Viewers

The interest in stereo has been given a big boost by computer games but it's now being widely displayed on the Web. Some forms of display don't require any special provisions, but others require a plug-in for your browser or Java capability.

DepthCharge

The Vrex DepthCharge plug-in allows you to view a variety of stereo image formats on the Web. The plug-in works on Windows 95/NT, using version 3 or higher of either Netscape or

Internet Explorer. It supports the following viewing technologies:

- Cross-eye view images
- Parallel view images
- Anaglyph images using red/green glasses
- Page flipped images with shutter glasses
- Line alternate images for shutter glasses and head mounted displays
- Squished side by side images for lenticular displays



[The VRex DepthCharge plug-in](#) allows you to view a variety of stereo image formats on the Web. You'll see this logo on many sites that support the plug-in.

When you are browsing the Web with DepthCharge installed, you'll find monoscopic or flat view DepthCharge images that you can view just like any other image on the Web. When you point to one of these DepthCharge images, your mouse pointer will take the shape of 3D glasses. (Note that some sites display thumbnails that you must first click to display the DepthCharge image.) To display the image in 3D, just click it. To return to the normal browser view, click it again. To specify which view to display it in, right-click the image to display a pop-up menu.

SimWeb3D

[SimWeb3D](#) is a Java plug-in for your Windows Web browser that works with SimulEyes™ glasses.

Making 3D Images

In the old days, stereo photographs were mounted side by side on a card or printed on top of one slightly out of register. Today, this work can be done on the computer using a variety of software.

3D Stereo Image Factory™ by SOFTreat

Stereo 3D images can be viewed in [3D Stereoscopic Image Factory](#)™ in many ways. On the low-tech side this includes free viewing as parallel or crossed side by side pairs or with red/blue glasses as anaglyphs. On the Hi-tech side there are Liquid Crystal Shutter Glasses which operate with images prepared for interlacing, page flipping, or sync doubling. Work in your favorite 3D format and explore all the other types too.

Photoshop

You can create anaglyph images with [Photoshop](#).

1. Start with a stereo pair.

2. Remove the red component from the right image.
3. Remove the green and blue components from the left image
4. Superimpose the two images

StereoVR

StereoVR allows you to create your own stereoscopic 3D images and animations. It includes a modeler to make your own 3D mesh wireframes, an extensive library of objects, lighting, colors and textures to render in full color 3D, and an animator to propel your creations right from the computer monitor.

VRex STEREO IPAS

3D Studio users can render stereo 3D images with Vrex's [STEREO IPAS](#) plug-in module. This software runs in the 3D Studio keyframer to automatically position two cameras in your already existing or new 3D scenes so the correct left and right perspective views are computed and rendered. You then multiplex the two image files with any VRex S-MUX program.

MUX-IT

MUX-IT is the VRex program that combines left and right images into a 3D image using the Spatially Multiplexed Imaging (SMI) technique. Pixel rows of the left image are interleaved with pixel rows of the right image to produce a single stereo image for display through the patented μ Pol optical system.

S-MUX

VRex's most popular stereo multiplexing software, S-MUX provides a familiar interface to easily select and multiplex your graphics into Spatially Multiplexed Images (SMI) for viewing on any VRex 3D display system. Just click on the graphics files for your left and right perspective views, click on the Multiplex icon and you're done! For special 3D graphics applications you'll appreciate the full range of features in S-MUX including real-time editing, parallax adjustment, image scaling, batch animation mode, and more. Available for DOS, Windows and Macintosh.

Stereo Panoramas

The best of all worlds are stereoscopic panoramas. There are a couple of tools available to capture such images.



With PanDC, you can create stereographic images that approach 120° in each half of the stereo pair. To achieve a stereo effect, a series on 15 or more images is taken with the camera moved to the right between exposures of each pair. The distance that you move the camera, called the stereo base distance, depends partly on the scene (you have to experiment). To see this one, first click it to enlarge it. Image courtesy of [Orphan Technologies](#).

By mounting two cameras side-by-side as you take a series of pictures for a panorama, you capture a series of stereo pairs. By stitching those from each camera together into it's own panorama, you create a panoramic stereo pair. I've never done this, so I can't tell you how well the pairs will match. If you know, please [drop me a note](#).



The Kaidan QPST-1 allows you to mount two 35mm cameras side by side for creating stereoscopic panoramas. It's not usable separately, but is an add-on to Kaidan's QP-4 and QP-6 panoramic brackets. Image courtesy of [Kaidan](#).

CHAPTER 13, PHOTOGRAPHY AT WORK



1.0 PHOTOJOURNALISM

Platt D. Babbitt. [Man stranded on rocks in the Niagara River] quarter plate daguerreotype, 1853.



In 1853, Platt Babbitt opened a daguerreotype studio at Niagara Falls. He was probably the first daguerreotypist to specialize in tourist photography by taking images of people watching the Falls. This view is an early news photograph. Two men boating in the Niagara River were overwhelmed by the river's strong current, lost control of their boat, and crashed into a rock. The current carried one man immediately over the Falls to his death. The daguerreotype shows the second man, stranded on a log which had jammed between two rocks. He weathered the current for eighteen exhausting hours before succumbing to the river. Courtesy of the [Library of Congress](#).

Appendix

BUYING A DIGITAL CAMERA

If you don't have a digital camera and are trying to decide whether to buy one, you've got some thinking to do. To be honest, digital photography is still not as good in many ways as traditional film photography. However, it's only when large prints or very high image quality are important that affordable digital cameras suffer by comparison.



The Nikon D1, a digital camera for professionals. Courtesy of [Nikon](#).

It's interesting to reflect back that image quality has not historically been the determining factor in which photographic process becomes most popular. The superb image quality of the daguerreotype was superseded first by the much inferior ambrotype and then by the even worse tintype. Over the history of photography, photographers have shown a willingness to forgo some quality for cheaper, easier processes. However, in the digital arena, what often appears to be inferior is really just different. An 8 x 10 color print from an inexpensive ink-jet printer may not look quite as good as an 8 x 10 print made at a leading photo lab, but it has its own charm and is much better than mass market enlargements. Any differences are not drawbacks, but opportunities to be artistically exploited.



Tintype photographer at the Champlain Valley Exposition in 1941. Courtesy of the [Library of Congress](#).

The Curse Of Moore's Law

Anyone who has bought a computer knows the perennial questions, "Is now the time to buy, or would it be better to wait?" As the ability to put more and more transistors on a chip increases, the cost per unit of computing power falls. In 1965 Gordon Moore, one of the founders of Intel Corporation, predicted that the density of transistors on a chip would double every year and a half. His prediction, known as Moore's Law, has turned out to be very accurate. In 25 years, the number of transistors on a chip has increased from 2,300 on the 4004 in 1971 to 7.5 million on the Pentium® II processor in 1998. At this rate, Intel chips will contain 50-100 million chips by the year 2000 and will be able to execute 2 billion instructions per second.

Moore's Law drives innovation forward at a disturbing rate. In this environment it's only natural to think you should wait to buy a digital device because in six months you'll get much more for your money—and you're right! The problem is that you can use this rationale to delay a purchase for years, and even decades. New and improved models will always be six months away. In the computer world, power users buy their computers when they need them, knowing full-well that they'll pass them on in a few years and replace them with newer models. If you're really serious about photography, you may have to shed your old willingness to invest in a new camera system every decade or two and replace it with a 2-3 year time frame.

Probably the biggest question of all is whether you want to buy a digital camera at all. There are pros and cons to the decision and you don't need a digital camera for digital imaging. You can always use a standard film camera and have selected slides or negatives scanned at your local photofinisher. Here's a table that weighs the pros and cons of each approach.

Professional level controls are found on even the cheapest 35 mm SLR. There is also an extensive choice of lenses for most models.

The Rules of the Shopping Game

Buying a camera or any digital product can be confusing at best. In this section we explore some of the rules of the game and point you to some places where you can do your homework right from your desktop. Why drive from store to store or fight the crowds at photo shows when you can just click your way around the digital-imaging world?

One site you might want to look into is the [Active Buyers Guide](http://www.activebuyersguide.com/) (<http://www.activebuyersguide.com/>). When you select digital cameras, you can list your priorities and the features you are looking for. The program then does a search for you and lists the cameras that match your criteria.

Check Deja News

News groups are where people ask questions and get answers. There is no better place to find out what others are saying and thinking. Before selecting a camera or a dealer, you might want to see what people are saying about them at Deja News (<http://www.dejanews.com>). This site allows you to enter a name to search for and it then lists all of the postings containing that word. For example, to find out what people are saying about the Mavica cameras, just enter Mavica and you'll find all postings about this camera. To find out what people think of an on-line retailer such as PC Connection, just enter PC Connection. This gives you a chance to hear what other people's experiences have been. Every company has dissatisfied customers so don't let one or two put you off. What you want to know is how a company handles complaints and if there is a pattern to them?

Check Price Comparison Sites

Price comparison sites, sometimes called shopping agents, scan other Web outlets for products and prices. If you're looking for a specific item, these sites are a good place to start. Just be aware that payments or other favors may be being exchanged behind the scenes that affect listings and rankings. Use these sites as a guide, not as the last word. Here are some of the better known sites:

- PC Photo review (<http://www.dpstore.com/>)
- 20-20Consumer (<http://www.2020consumer.com/>)
- PriceScan (<http://www.pricescan.com>)
- PriceWatch (<http://www.pricewatch.com>)
- CompareNet (<http://www.comparenet.com>)
- Excite Product Finder (<http://www..com>)
- Killerapp.com (<http://www.killerapp.com>)
- Shopper.Com (<http://www.shopper.com>)

Explore On-line Auctions

There are people who swear by Web auctions as a way to get the lowest possible price. There are even people addicted to these sites. The best thing about them is that you can enter low bids and maybe get a real deal. Before beginning, be aware that the National Consumers League, in a United States Senate hearing, listed Web auctions as the No. 1 fraudulent scheme on the Internet, based on the number of complaints they and state attorneys general received. According to the League, common complaints are that items bid for are never delivered by the sellers, the value of items is inflated, shills are suspected of driving up bids, and prices are hiked after the highest bids are accepted. Here are some of the better-known on-line auction sites.

- EBay (<http://www.ebay.com>)
- Onsale (<http://www.onsale.com>)
- FirstAuction (<http://www.firstauction.com>)

Watch Out for Unbundling

When you buy a digital camera, the basic package almost always includes extras such as a battery charger, lens cap, batteries, flash memory card, and software. One of the more disreputable practices a dealer can engage in is called unbundling. These dealers remove items from the package that are normally included in the price and price them separately. To find out what should be included in the package, visit the camera manufacturer's Web site and check their specifications page. The included items are almost always listed. The user's guide that comes with the camera will also list the items that should be included as part of the camera price.

Avoid Gray Market Products

When camera companies introduce new cameras, they frequently use different product numbers, names, and prices in different markets around the world. Some dealers buy cameras in countries with the lowest prices and then sell them in another country. Since these cameras are bought and sold outside of the manufacturer's normal distribution channels, prices may be lower but you almost always lose warranty coverage and technical support.

Check Postage and Handling Rates

When purchasing a camera you have three components of the price to consider—the camera price, postage and handling, and taxes. When you purchase over the Web or by mail order from an out-of-state-company, you and not the dealer are responsible for paying state and local sales taxes. Most people aren't aware of this responsibility, or choose to ignore it. (Now that you're aware of it, you have to make the moral judgement.) When it comes to the price and postage and handling, however, the dealer is in control. Many dealers lower the price to make the camera more attractive, then increase the postage and handling to boost their profits. With the popularity of price comparison sites such as PriceScan (<http://www.pricescan.com>), the temptation to do this is even stronger. Be sure you ask about

have deals with firms such as Federal Express so their costs are \$5 or so for second day shipments. Anything over and above that is pure profit to the dealer.

Avoid Extended Warranties

Hesitate before accepting extended warranties. Every knowledgeable consumer expert says it's better to gamble. Most of a company's profit is in the sale of these warranties so they press, and press hard. Your job is to resist, and resist hard. The only thing to keep in mind is that digital cameras can be horribly expensive to repair. If you want peace of mind, you may want the warranty, even though it's probably overpriced.

Check Return Policies, Restocking Fees

When you buy a camera from a reputable dealer, you expect to be able to return it if you aren't satisfied. Some dealers try to discourage this by requiring a restocking fee for returned merchandise. This is always explained as a way to recover their costs of checking the merchandise and restoring the packaging you may have opened. If a dealer requires a restocking fee, my advice is to find another dealer.

Buy no Extras

Buy no extras without doing research. A few dealers low-ball camera prices and make their profit on the other things their high-pressure sales people can stick you with.

Camera Selection Checklist

If you're buying a digital camera for the first time, you can quickly get lost in the details—there are lots of them. However, before looking at specifics, you should think through how you want to use the camera and its photos.

- Will you be shooting indoors? This will determine the quality of the flash you need.
- Will you be photographing static scenes such as home interiors, or action shots such as sports? This will determine the best viewfinder and lens.
- Will you be photographing wide angle scenes such as landscapes and home interiors, telephoto scenes such as portraits, or close-ups such as stamps and coins? This will determine the focal length of the lens you need and whether you need a zoom lens, auxiliary lenses, or macro mode.
- Are you a casual user, or a serious amateur or professional photographer? This will help you determine how many manual controls you'll want on the camera.
- Will you print the photos as snapshots, enlargements, or embed them in word processed or desktop published documents? Or will you publish the images on a Web page, e-mail them to others, or include them in a presentation? This will determine the best resolution for your situation.

There are so many digital cameras with so many different features that it's hard to compare them unless you know what features are available and how they affect your photography. Here is a checklist of features you can use when choosing a camera for yourself. Just keep in mind that a checklist provides only a rough guideline because a list of features and specifications doesn't always tell the whole story. Lens quality is hard to quantify, as is the

quality of the software inside the camera that's messing around with every image you take. To make the best camera choice, read reviews from sources you trust and try to look at side by side comparisons of images.

Camera Types

Item	Comment
Point and shoot camera	Minimal control but easy to use. Prints up to about 5 x 7.
Megapixel camera	Better prints, good up to 8 x 10.
Multi-megapixel camera	Even better prints and even larger file sizes. Great prints up to 8 x 10 and larger.
Professional camera	Expensive but lots of creative control.

Image sensor

Item	Comment
CCD image sensor	Highest image quality, more expensive.
CMOS image sensor	Lower image quality but less expensive.
Resolution	Greater resolution permits larger prints.
Aspect ratio	The ratio of the sensor's width to height.
Color depth	30 is great, 24 is OK.
Sensitivity	Higher ISOs mean more "speed" or sensitivity so less light is needed for a good exposure.
Image quality	Less compression is better but you can't store as many images. Uncompressed format is best but image files are very large.

Image Storage

Item	Comment
Type of storage media	PC Card, CompactFlash, SmartMedia, other.
Removable media	Removable media allows you to remove a full storage device, insert a new one, and keep on shooting.
Storage capacity	Higher capacity devices store more images.

Downloading Images

Item	Comment
------	---------

Serial cable	The slowest port on the computer.
Parallel port	The second slowest port on the computer but much faster than the serial port.
SCSI port	A fairly fast port but can be difficult to configure.
USB port	The fastest port that is widely available. Ideal for transferring digital photographs.
IEEE 1394 (Firewire) port	The fastest port on the horizon, but not yet widely available.
Card adapter	An adapter into which you insert a storage device so it can be read by the computer, printer, or other device.
Card reader	A small device connected to a computer port by cable. To transfer files, you remove the storage device from the camera and insert it into the reader.
Infrared connection	A wireless way to transfer images between devices. Not very fast and connection is blocked by obstacles.
Direct download to a printer	Some camera-printer combinations allow you to bypass the computer when you want to print images.
Video out, television display	NTSC (USA) or PAL (Europe) connections allow you to display images from the camera on a television set.
Direct e-mail from camera	Allows you to e-mail images directly from the camera.
Direct Web posting	Allows you to post images on a Web site directly from the camera.

Image Compression & File Formats

Item	Comment
JPEG	Most common digital camera image format.
CCD Raw	An uncompressed image format that contains all of the data picked up by the image sensor.
TIFF	The most widely used lossless image format

Preview Screens & Viewfinders

Item	Comment
Preview screen, size	LCD preview screens are used to compose or review pictures.
Optical viewfinder	An optical viewfinder is used to compose images. It requires no power. This design has a separate viewfinder window slightly offset from the lens.
Thru-the-lens viewing	This design shows you the view through the lens when you look

	into the viewfinder.
--	----------------------

Lenses

Item	Comment
Focal length	Determines the angle of coverage.
Zoom lens	Optical zooms are better than digital zooms.
Macro mode	A lens mode that lets you get very close to small objects to show them greatly enlarged.
Interchangeable lenses	Interchangeable lenses let you change focal lengths.
Lens accessories	Some camera make it easy to attach lens accessories such as filters or adapters, other make it hard.
Maximum aperture	Larger apertures are better in low light or when capturing fast action.
Detachable/rotatable lenses	Allow you to position the camera body and lens independently to shoot over crowds or around corners.
Glass or plastic?	Glass lens are generally better than plastic lenses.

Creative Controls

Item	Comment
Automatic mode	Camera sets both aperture and shutter speed.
Exposure compensation	You can adjust exposure one or two stops in either direction to lighten or darken scenes.
Shutter priority mode	You set the shutter speed to control motion and the camera selects the best matching aperture.
Aperture priority mode	You set the aperture to control depth of field and the camera selects the best matching shutter speed.
Manual mode	You set bot aperture and shutter speed.
Focus, fixed	Unadjustable focus is preset.
Focus, automatic	Camera focuses on subject in the middle of the viewfinder.
Focus, manual	You focus the camera so you can determine what's in focus and what isn't.
Focus range	How close you can get to a subject.
Exposure/focus lock	You point to anything and hold down the shutter button halfway to lock in exposure and focus settings.

White balance	Adjusts the image sensor for the type of light under which you are photographing. Can be automatic or manual.
---------------	---

Automatic Flash

Item	Comment
Flash range	The maximum range at which the flash illuminates a subject.
Flash mode, auto	The flash fires when there isn't enough natural or artificial light to get a good exposure.
Flash mode, off	The flash won't fire so you can use natural light even when the light is low.
Flash mode, fill or forced	The flash fires even when there is enough light for a good exposure. Good for filling shadows on sunny days.
Flash mode, slow sync	Let's you adjust the relative brightness of the foreground subject illuminated by the flash and background subjects illuminated by natural light.
Red-eye reduction	Fires a first flash to close the subjects iris before firing the second flash used to take the picture.
Hot shoe, sync connector.	Allows you to remove the flash from the camera.

Batteries etc.

Item	Comment
Alkaline batteries	Inexpensive but don't last long and aren't rechargeable.
NiCad batteries	Suffers memory problems if not charged properly.
NiMH batteries	The current first choice for digital camera batteries. Rechargeable and no memory problems.
LiOn batteries	Longest lasting batteries but the most expensive. Rechargeable and no memory problems.
Battery charger/conditioner	Recharges batteries.
AC adapter	Plugs the camera into a wall socket so you can keep shooting when your batteries are dead.

Other Features

Item	Comment
Look and feel	Try it, see if you like it.
Size and weight	The smaller and lighter it is, the more likely you are to take it with

	you.
Orientation sensor	Rotates portrait mode images so they are turned sideways on the preview screen, TV and, computer screen.
Burst mode	Shoots a series of pictures one after another at a high rate.
Time-lapse mode	Shoots a series of pictures at preset intervals.
Video mode	Shoots a few seconds of minutes of video with sound.
Panoramic, single image	Takes one image using just the center band of the image sensor.
Panoramic, multiple image	Guides you through a series of images which you then stitch together into a single image on the computer.
Multiple exposures	Let's you take multiple images so they overlap one another.
Tripod mount	A place into which you can screw a tripod.
Self-timer	The camera fires at the end of a preset period of time.
Remote control	You can fire the camera from a distance with a wireless remote control.
Date/time indicators	Images are date and time stamped.
Written annotation	The preview screen you can write on to annotate pictures.
Sound recording	The camera contains a microphone so you can record comments about your pictures.
Software	This varies widely from camera to camera but usually includes download software and a photo-editing program.
Operating system	Most operating systems are unique to a specific line of cameras. The only exception is Digita that allows you to write scripts to automate camera functions.