Chris Friesen's

rec.photo.digital FAQ

Last-modified: **2000/11/23**
Version: **0.5**

This version is extremely preliminary, please don't send me any comments on the formatting, etc. I haven't tweaked it yet. Please do send any suggestions for questions I'm missed or corrections to any mistakes or omissions that I've made in my responses.

Send corrections and updates to Chris Friesen (chirs@bigfoot.com). If you have a question you'd like to see answered in here, either post it to the news:rec.photo.digital newsgroup with a mention of FAQ in the subject line (if you don't have the answer), or send it to chirs@bigfoot.com (if you do).

If you're reading this on a web page and want to check out the newsgroups, check out the following with a news reader. news:rec.photo.digital If you don't have one, you can read news and search for past articles on http://www.dejanews.com/:

The HTML version of this FAQ is available from:

http://www.crosswinds.net/~rpdfaq

The text version of this FAQ is posted to Usenet and can be obtained at http://www.crosswinds.net/~rpdfaq/rpdfaq.txt

Please DO NOT post copies of the HTML version on your web site. I wish to avoid getting e-mail from people reading versions that are several months old. You should include a link to the www.crosswinds.net site instead.

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Subject: [0] Introduction

Subject: [0-1] Legal noise (disclaimers and copyrights)

(2000/04/16)

Free distribution of the this FAQ is encouraged, as are conversions to HTML or other formats and translation to foreign languages, so long as no content is removed, and additions are clearly marked. The plain ASCII text and www.crosswinds.net HTML versions aren't restricted, but other conversions might be (the content is free, the presentation might not be). Check with the publisher.

The date and version number on the FAQ **are** considered part of the content that must not be removed. I do not want to get messages from people who don't realize that the copy they're reading is a year old.

> Caveat lector: the information here is mostly derived from Usenet postings, e-mail, and information on WWW sites. As such, it may well be DEAD WRONG, and you are encouraged to verify it for yourself.

I take no responsibility for damaged hardware, time lost, or any other damages you incur as a result of reading this FAQ. Information on specific models of hardware and software is based on **opinions** of other users, not scientific studies. I am not an expert in this (or any other) field. Everything here could be a total malicious lie, and should be treated as such. You have been warned.

I don't get paid to plug anybody's software or equipment. The sections on "what XXX should I buy" are not here because I want to sway purchases one way or another, they're here because the questions are asked **a lot**, and the answers are pretty consistent. You are invited and encouraged to investigate the capabilities and reputations of all products.

The various product and company names are trademarks of their respective companies.

Visit http://www.clari.net/brad/copymyths.html for a mini-FAQ on copyright laws.

Subject: [0-2] What does this FAQ cover?

(2000/04/16)

This document attempts to answer Frequently Asked Questions about ditigal imaging technology and related fields. It is a Usenet newsgroup FAQ, updated and posted around the middle of each month, or when I can spare the time. The main foci are explaining digital imaging technology, describing hardware and software solutions for creating digital images both on the computer and physical printouts, and helping people find solutions to common problems.

I don't usually address questions that can be phrased, "how do I make my software do this?" The answers to those should be in the manual that came with your software. In general, this is a collection of answers to specific questions, not a "how to" guide. I also don't try to track moving targets, like digicam firmware versions or software versions unless a specific release is especially interesting.

Subject: [0-3] What's new since last time?

(2000/04/16)

All sections are tagged with a modification date, so you can see how long ago something was revised. If you want to know **everything** that has changed since last time, you may be able to get a set of "context diffs" from http://www.crosswinds.net/~rpdfaq/txtdiffs.zip . I may or may not have them up by the time you get there.

Highlights:

This is essentially a preliminary draft of this FAQ, hence the version number being less than one.

The web URL and the email response address have been changed, as I will be out of the country for three months and hence the previous address (hosted at my ISP) will no longer be valid.

I have tried to find a host that would be free, and not have those annoying popup windows. Crosswinds was okay, but now they seem to have a popup, so I may be changing the URL at some point in the future.

Subject: [0-4] Is the FAQ only available in English?

(2000/04/16)

As far as I know, yes.

French, German, Italian, Portuguese, and Spanish translations can be done through http://babelfish.altavista.digital.com/cgi-bin/translate . This is an automatic language translator that is HTML-aware. It only translates the first part of each document, so it's not entirely helpful if you just want to read a translation, but it may make doing a full translation much easier. (The translation is pretty good for an automatic translator, but is still pretty rough. I don't want to post a translation that is inaccurate or misleading, so I'm not going to run the FAQ parts through babelfish automatically.)

If you're interested in translating this FAQ, you are welcome to do so, but please respect the amount of work that I and others have put into it. Don't strip out sections, remove author attributions, or hide the revision date of the document. I don't think the terms in section (0-1) are terribly restrictive. If, for whatever reason, you can't keep up with every update of the English version, that's fine; all I ask is that you include a link to the master English version, so that the current information is easily locatable. (Some commonly updated things, like the list of hardware in section 8, don't need much translation.) If you don't want to translate a particular section, just leave it in English.

If you want to start with an HTML version, use the pages from http://www.crosswinds.net/~rpdfaq .

If you do a translation, let me know and I'll put the URL here.

Subject: [0-5] Appropriate use of the newsgroups

(2000/04/16)

This FAQ covers the news:rec.photo.digital newsgroup

Here are a few guidelines. These aren't hard and fast rules -- nobody died and put me in charge of making the rules -- but if you're not sure what the appropriate subject matter is then this may be helpful.

Appropriate material includes questions about past, current, and future digital imaging devices and software. Asking for help or advice on what to buy or how to best perform a specific task is appropriate, as are questions about related hardware like card readers and possibly CD burners (useful for backup purposes).

Some general rules apply to the news:rec.photo.digital group:

1. Piracy of software: CD recorders can be used to make copies of copyrighted material, and while backups of data are legal, making or accepting copies from others most likely isn't. Whatever your opinion of the matter, software piracy and other copyright violations are illegal in most countries in the world, so requests and/or advertisements for pirated material should be kept off the newsgroup. Also, please don't start or participate in a debate about whether or not software piracy is bad. There have been hundreds of such debates over the past several years, and the only thing that either side has managed to prove is that piracy debates are a tremendous waste of time.

2. Personal digital imaging hardware and software sales: these groups aren't appropriate for selling off your old hardware or software. Such things are best left in news:rec.photo.marketplace.digital and related groups. There have been some debates over this topic in recent months, but the charter of the group as it stands is quite clear on this - advertisements and for sale notices should not be posted to the news:rec.photo.digital newsgroup.

3. Digital imaging product advertising: The news:rec.photo.digital group is not for advertising. For that purpose, PLEASE use the news:rec.photo.marketplace.digital newsgroup. Also, posting frequent and useless followups just to broadcast your 20-line signature will get you flamed and subsequently ignored. Feel free to send mail to people who post questions about product pricing and availability, but please don't create mailing lists and broadcast to everyone who posts.

4. Other advertising: Please keep ads in newsgroups that are more appropriate. Advertising the latest educational, game, or adult CD is inappropriate for these groups, as are "hot new Cyrix 686 PC" posts. Not-so-subtle attempts to advertise web sites ("golly, this looked really neat, so I thought I'd tell everyone") are more obvious than you might think.

5. Spam: you cannot make money fast. That's life, get used to it. If the message involves putting your name at the top of a list of 5 or 10 people, don't post it. If it has an 800 or 888 number that a reader would call to hear more about your unique business opportunity, don't post it.

6. Binaries: as with most Usenet newsgroups, posting binary files (large or small) is inappropriate. If you want to make a binary file available to Usenet readers, the best way is to post the image to a website and post the link in the newsgroup.

7. Charter: the definitive word on what is allowable in the news:rec.photo.digital and related newsgroups may be found in their respective charters, at http://www.advanix.com/~photo/bobatkins/info/charter.htm

   One final note: bear in mind that these groups are read by people all over the world. If you're looking for local retailers, be sure to specify what "local" is for you. Posting in English is the best way to ensure that you will get a response, but the readership is diverse enough that you will likely get a reply no matter what language you use. If you want to quote prices, specify the currency to avoid confusion (e.g. US$300 or CAN$300 or Y30000 or ...).

Subject: [0-6] I'm having trouble, how do I ask for help?

(2000/11/23)

The first thing to do is look at the web pages for the products you're using. Sometimes there will be software or firmware updates, or pages with information on common problems. Scanning through www sites and news archives on servers like www.altavista.com or www.deja.com will often turn up relevant material.

If you don't find anything, calling or sending an e-mail message to the technical support department for the product that is giving you trouble is a good second step. If you want to contact other users, posting a message to one of the Usenet newsgroups is a reasonable thing to do.

You will get faster, more accurate responses to questions if you include enough detail in your mail message or news posting. For most problems having to do with imaging, you need to specify:

1. Hardware. Camara type, PC type, whatever is applicable.
2. Operating system, with version, if applicable. Win95, Win98, WinNT4, Win2000, etc.
3. Camera or scanner brand, model, and firmware revision, e.g. "HP Photosmart C5100A v1.00".
4. Other relevant hardware details. If the camera can interface using serial or USB, specify which you were using. For SCSI device problems, listing the other devices on the chain may help.
5. Software in use, including version numbers, e.g. "Photoshop v5.5".
6. What were you trying to do? What specific steps did you take to go about it? Have you tried anything to correct the problem, and if so, what were the results?

7. Specific error messages seen. Write down **exactly** what it says, add any numeric error codes along with it. Be sure to write down what it **said**, not what you think it **meant**. Add your interpretation of events only after you've gotten all the details down.

Try to include any details which you think might be relevant. Take the time to organize your report so that it is easy to understand. And PLEASE check this FAQ for the answers first! Much of the volume on the newsgroups is from people whose questions are already answered here.

Subject: [0-7] Spelling and name conventions

(2000/11/23)

Whenever possible, the FAQ tries to use the correct spelling and terminology. Errors may be reported to the FAQ maintainer, but bear in mind that I don't modify the contents of quoted material, the names of products, or the titles of articles and web pages.

The most common mistake is:

Using "resolution" to denote an image size in pixels. "Resolution" must be related to physical size, not just the number of pixels in an image. DPI, PPI, and LPI are all measures of resolution, while "1280x1024" is not. When talking about the size of the image, simply refer to "image size".

Some terminology:
"K" or "k" stand for kilo, or 1000. When dealing with computers, it is generally 2^10, or 1024. Proper SI notation is to use a small k, but this is generally ignored in computer usage. "M" stands for mega, or 1000000. When dealing with computers, it is generally 2^20, or 1048576. When dealing with numbers of pixels, however, it is usually taken as the SI value of one million exactly. "B" stands for a byte, which is 8 bits.
"b" stands for a bit.

Thus, KB is 1024 bytes, or 8192 bits, wile Mb is 1048576 bits.

Subject: [0-8] Can I advertise on the FAQ pages?

(2000/01/19)

Not really. In an effort to keep the FAQ fair and impartial, I don't accept advertising. Vendors with relevant products can have URLs added to appropriate sections of the FAQ. Vendors without URLs for their products aren't usually listed.

Products that solve specific problems, such as image editing, image thumbnailing and cataloging, and such, will be listed under the appropriate topic. Vendors that don't fit in a specific category will be listed in a separate section.

Subject: [0-9] Can you mail the FAQ to me?

(2000/01/19)

I'm not set up to act as a mail server, so your best bet is to find someone that can get it off the web for you.

Subject: [1] Simple answers to simple questions

Subject: [1-1] What is a digital image?

(2000/11/23)

A digital image is an image that is at some point converted into digital form for convenient manipulation by a computer or other digital device. The images discussed in this newsgroup are most commonly of the type known as "raster" images, where each pixel is represented individually (although they may be compressed for storage, depending on the file type).

There are a number of different formats, but the most common for photographic purposes is the 24-bit RGB image, where each pixel consists of a single byte of information for each of red, blue, and green. This means that each of the three colors can have 256 individual intensity shades, giving 16.7 million shades in total. Other formats include greyscale, CMYK, LAB, and others. Greyscale is useful for storing black and white images, but the others are useful only in certain circumstances which are beyond the scope of this document. If you don't know what they are already, you probably shouldn't be using them.

Subject: [1-2] What do people mean when they talk about resolution?

(2000/01/19)

There is a common error made regarding the term "resolution"-indeed, I've made it myself. This improper usage of the term uses "resolution" as simply the size of the image; as in, "The image resolution was 1600x1200 pixels."

Properly speaking, "resolution" should only be used to discuss the amount of detail present or resolvable within a certain distance. Thus, valid measures of resolution would include dots per inch (dpi), pixels per inch (ppi), and lines per inch (lpi). Notice the length term present in each of these. Without this length term, it cannot be denoted as a measure of "resolution".

Subject: [1-3] Okay, so what is the difference between dpi, ppi, and lpi?

(2000/11/23)

Dots per inch is generally used to quantify the output of printers. In this usage, it means that a given number of dots of a single color can be printed within a certain distance. Thus, the rated resolution of a printer is valid only in line art mode. As soon as you try to print shades of grey or colour, the effective resolution of the output goes down since you need to blend dots of different colors. See the section on printer resolution for more information on this.

Pixels per inch is the proper term to use when specifying the resolution of a scanner. The ppi rating of a scanner is the number of pixels (each composed of red, green, and blue values) that can be sampled within the space of an inch. Thus, a film scanner rated at 4000ppi would be able to sample 6000 pixels along a segment of film measuring 1.5" long.

Lines per inch is the normal way to test the resolution of optics and film in the analog domain. A printed target of black lines is used to determine at which point you can no longer distinguish between the lines. Since there is white space between the black lines, it actually would take a line of white and a line of black to give a single "line" of resolution. (Actually it takes more than one pair, but that's getting into sampling theory and we don't want to go there.) Thus, a scanner capable of 1200ppi resolution, would be theoretically capable of a maximum of 600lpi.

Subject: [1-4] How do I get a digital image into my computer?

(2000/11/23)

There are two ways to get an image of a real-world object into the computer-a digital camera or a scanner.

The digital camera uses lenses to project an image of the actual object onto a light-sensitive charge-coupled device (CCD) or complimentary metal-oxide semiconductor (CMOS) sensor. The CCD or CMOS sensor then converts the image directly into digital form, at which point it may be stored or sent to the computer. Digital cameras may be used anywhere that film cameras are used, and generally look similar to film cameras.

The scanner takes an analog image and converts it to digital. The original item is placed in the scanner, at which point a digital image is sent to the computer. Flatbed scanners are useful for scanning prints and three-dimensional objects, while film scanners are generally higher resolution and are optimized for negatives and slides. Scanners require at least two steps (nature->film->digital) as opposed to the single step (nature->digital) of the digital camera.

Subject: [1-5] What is better to obtain digital images, a scanner or a camera?

(2000/11/23)

It really depends what you want to do. At present, digital cameras in the price range even remotely affordable by the amateur are quite limited in their pixel size. Currently they are in the range of 2000x1500, with some going somewhat larger. This limits your print size to about 5"x7" at near photographic quality. It is possible to do a pretty good 8"x10" and even a decent 11"x14", but it is noticeably softer than the 4"x5". If this range of output size is satisfactory, or if you are only going to be displaying the images on a computer screen or LCD projector, then a digital camera should suit you just fine.

If, on the other hand, you want a larger print, or want to be able to crop and still print the image at the above sizes, then you'll need to spring for a scanner. In this case, dedicated film scanners give the best results, but flatbed scans of prints can give excellent quality as well.

Subject: [1-6] How do I learn more?

(2000/01/19)

This FAQ contains a great deal of information, but it's geared toward answering specific questions rather than providing a general education. Some of the other net resources are more like a tutorial than a Q&A list, and may provide a better starting point.

A great place to go for information on how to get the most out of your scanner is http://www.scantips.com

Subject: [2] Scanners

Subject: [2-1] How do scanners work?

(2000/01/19)

Briefly, scanners shine a light on (or through) a subject, and then an array of sensors picks up the image and converts it to digital form.

They are called "scanners" because the array is in the form of a line that stretches the width of the original, and that array must be "scanned" along the length of the original.

So the array would start at one end and store the results for each pixel. It would then move a bit further along and take another reading. This process would repeat until it has moved the length of the entire original, and it has constructed a digital image of the entire original.

Subject: [2-2] What different kinds of scanners are there?

(2000/01/19)

There are two kinds of scanners which we will be considering, flatbeds and film scanners.

Flatbed scanners are designed for reflective material, which means that the light source (generally an fluorescent bulb) and the sensor array are on the same side of original. Flatbeds are generally able to accept inputs of up to letter or legal size (8.5"x11" or 8.5"x13"). Larger scanners do exist, at a much greater price. These are the typical scanner that you see at any computer store, and cheap versions of this type of scanner often come bundled with computer systems. Consumer flatbed scanners can have resolutions up to 1200ppi, although some professional (and extremely expensive) scanners have resolutions that are quite a bit higher.

Flatbed scanners are capable of doing an excellent job of scanning prints, magazines, artwork, and even small objects. They are not so good at scanning negatives or slides, mainly due to the comparatively low resolution of the scanner. Also, a transparency adapter is required. This is basically a box that shines light through the film so that it registers on the scanner's image sensor-you can't bounce light off the film like you would a photo, you need the light coming through it.

Film scanners are optimized for film (including both negatives and slides). This means that they are designed to handle smaller originals (from aps to medium format in size), and they are designed for non-opaque originals. This means that the light source (either a fluorescent tube or an array of LEDs) is on one side of the original, while the sensor array is on the other side.

Film scanners generally have much higher resolutions than flatbeds, which is possible mainly because the originals are so much smaller. Film scanner resolutions in the range 2400-2880dpi are common, with the newer scanners coming in at 4000dpi. Most film scanners are optimized for 35mm negatives and slides, but it is possible to find ones that support APS and medium format as well.

Subject: [2-3] How many pixels can I get from a scanner?

(2000/11/23)

Well, a high-end consumer film scanner such as the Polaroid Sprintscan 4000 has a resolution of 4000ppi. With a standard 35mm negative, this would give a pixel size of 3780x5670 pixels, or a total of 21432600 pixels.

With a drum scanner, you can go even higher than this. A decent film has a resolution in the 6000 ppi range if the contrast of the image is high. For instance, Fuji Superia 100 has the equivalent of about 6000x9000 pixels. (Source: http://www.fujifilm.co.uk/technical/index.html)

Scanning from an 8x10 print using a flatbed at 600ppi, you would end up with an image size of 4800x6000 pixels, for a total of 28.8 million pixels.

In comparison, a high-end consumer digital camera will give up to 2240x1680 (for the Olympus E-10) pixels, or a total of about 4 million pixels.

Subject: [2-4] How do I get the pictures from the scanner to the computer?

(2000/01/19)

There are three ways that you can transfer the image from the scanner to the printer; SCSI, parallel port, and USB. I'll cover them briefly in order of fastest to slowest.

SCSI is one of the oldest, and in many ways still the best, of the transfer methods. The most common scanner interface is SCSI-II, which has a speed of 10Mbyte/sec. SCSI takes very little CPU overhead, and can be installed in any computer that has a free ISA or PCI slot. The two disadvantages to SCSI are the fact that you must install an expansion card in the computer (which can be tricky) and of course the additional hardware makes it cost more.

The ECP/EPP parallel port is the other oldster, supporting a transfer rate of 3 Mbyte/sec. The disadvantage with the parallel port is that it can take a lot of CPU time to run it quickly. Also, it can cause problems with the printer if it is not well-behaved. Machines that are older may not support ECP/EPP, in which case the SCSI scanner is a better option.

USB is a more recent method, but pretty much all new computers support it. It is much easier to install, as you simply plug in the scanner and feed in the driver CD when it requests it. Maximum throughput is 1.5 Mbyte/sec, but this is shared with all other USB devices on the system-so if you have a USB keyboard and mouse as well, they could be blocked out if the scanner saturates the USB bus.

Subject: [2-5] Who makes scanners?

(2000/01/19)

See section [8-2-1] for a list of scanner manufacturers.

Subject: [2-6] Which is the best scanner?

(2000/04/16)

This is a difficult question, as it depends on what you are doing with it.

For the high end of consumer 35mm film scanners, the choice at present comes down to the Polaroid Sprintscan 4000 (4000ppi, dynamic range of 3.4), the Minolta Scan Elite (2820dpi, Digital ICE, dynamic range of 3.6) and the Nikon LS2000 (2700ppi, Digital ICE, dynamic range of 3.6).

An excellent site for mostly objective reviews of film scanners is http://www.halftone.co.uk/tech/filmscan/ which has image comparisons of scans from a standardized Kodak Q60 calibration slide.

Subject: [3] Digicams

Subject: [3-1] How do digicams work?

(2000/11/23)

In a digital camera, a series of one or more lenses is used to project an image onto a light-sensitive charge-coupled device, or CCD. This CCD detects the image, and converts it to electrical signals, which are then converted into a standard image format and either stored on the camera or transferred to a computer. There are also some cameras using a complimentary metal-oxide semiconductor (CMOS) sensor, such as the Canon D30.

It should be noted that the vast majority of digital cameras use a single CCD, with a grid of color filters over the light sensors. This grid generally has twice as many green sensors as red or blue. Thus, at each pixel location a single color is actually sampled. To make the image, the values for the other two colors is interpolated based on the values of the surrounding pixels.

There is continuing debate over how much degradation this causes in the resulting image. On the one hand, two thirds of any given image from a digital camera is completely made up (sophisticated guessing, but guessing nonetheless). On the other hand, the eye is more sensitive to dark and light than it is to color, and there is a measurement of this quality (albeit for a single color) at each pixel location.

Going beyond the consumer level, there exist scanning backs for medium and large format cameras that actually do sample all three colors at each pixel location. These are extremely expensive, however, and are not suitable for moving subjects.

Subject: [3-2] How many pixels can I get from a digicam?

(2000/11/23)

This varies with the camera. Low-end ones will give 640x480 pixels, or sometimes even less. Current state-of-the-art consumer digital cameras will give up to about 2240x1680 (for the Olympus E-10) pixels, or a total of 3.76 million pixels.

In comparison, a high-end consumer film scanner such as the Polaroid Sprintscan 4000 has a resolution of 4000ppi. With a standard 35mm negative, this would give a pixel size of 5670x3780 pixels, or a total of 21.4 million pixels.

Again, going beyond the consumer level, it is possible to get a scanning back (Phase One PowerPhase FX) capable of 10500x12600 pixels, or a total of 132.3 million pixels. However, this device costs US$34000 and takes one and a half minutes to scan a picture.

Subject: [3-3] What is the difference between optical zoom and digital zoom?

(2000/04/16)

Zoom is technique which increases the size of the object of interest in the photograph. Optical zoom does this by manipulating the lens components to give a true increase in the size of the image projected onto the CCD. On the other hand digital zoom uses in camera software techniques to increase the size of the image on the finished photograph. Although digital zoom increases the size of the image in proportion to the size of the photograph it does so by eliminating the pixels in border regions of the image and expanding the number of pixels in the centre of the image. These "blank" extra pixels are filled with information derived from neighbouring original pixels. As such this involves guesswork (albeit fairly sophisticated guesswork) by the camera software and inevitably leads to some image degradation compared to the same results achieved solely by optical zoom. Most cameras with optical zoom also have some degree of digital zoom but is important to realize that although digital zoom may lead to increase d image size it does not lead to improved image quality and that the magnifying effects of digital zoom can be obtained in computer imaging software packages.

So in brief if you want zoom on a digital camera only pay attention to the optical zoom specs and not the digital zoom. The exception to this would be if you had no intention of using photo editing software on your images.

Subject: [3-4] What is better, higher optical zoom or more pixels?

(2000/04/16)

When trying to get a picture of something requiring zooming in, it has been noted that a camera with a larger number of pixels in the image can be cropped and give an equivalent image as camera with a smaller number of pixels but a longer lens. In order to get the best image, you want the subject to be covered by the most pixels possible. To compare two different cameras, calculate the comparison number using the following formula:

Comparison value = (35mm equivalent focal length)^2 * (number of image pixels)

The camera with the largest comparison value will give most pixels on a subject, which should give the best detail in the image.

Subject: [3-5] How are the pictures stored?

(2000/11/23)

The camera can be tethered directly to the computer, in which case the image is sent directly to the printer. More commonly, however, the image is written to some form of temporary storage while in the field.

The two most common forms of temporary storage are the floppy disk (used solely by the Sony Mavica series, and capable of holding up to 1.44MB) or flash memory (used by pretty much everything else, capable of holding up to 128MB, with capacity still increasing). Flash memory comes in two main forms, CompactFlash and SmartMedia. Sony has recently released a third form, called the MemoryStick.

As a side note, IBM makes a tiny hard drive called the MicroDrive that is compatible with CompactFlash type II, with a capacity of 340MB.

Finally, Sony has recently come out with a camera that writes the images to a 3.5" recordable CD-R disc. These store much more information than the floppies of the old Mavicas, and the media is relatively cheap and once full the discs are easily read by any normal CD-ROM drive. The camera is physically quite large, however.

Subject: [3-5-1] Which is better, flash memory or floppy disk?

(2000/01/19)

There is much debate on this topic. Proponents of the floppy point to its ubiquity, and state that its small capacity means that you never have too many images on a single disk if it gets lost or broken. They also point out that it is very easy to read the images into the computer-you simply insert the floppy into the computer's floppy drive.

Proponents of flash memory point out that the memory cards are much smaller, store much greater amounts of information, and are faster to read and write. The availability of SCSI and USB card readers means that it is much faster to import the images into the computer than it is to read images from multiple floppies.

An interesting point is that a floppy disk cannot store even a single uncompressed high resolution image, which is not acceptable for some people.

Subject: [3-6] How much storage do I need?

(2000/04/16)

Most digicams come with a pitifully small memory card, forcing people to go out and buy more. The question then becomes, what size do you buy? With flash memory sizes from 8MB-340MB, this can be a difficult decision.

The first thing to ask yourself is, how many pictures do I expect to take before I will be able to download them to a computer or laptop? The second question is, how big are my typical images? This will be influenced by the image size that you shoot at, as well as the compression mode that you use. Finally, multiply the two numbers together, and that will give you an idea of how much flash memory you will need.

Just to be on the safe side, I would add a bit more over whatever you calculate, as you don't want to be stuck with the image of a lifetime in front of you, and there you are trying to decide what images to delete to make room for it...

Subject: [3-7] How do I get the pictures from the camera to the computer?

(2000/01/19)

This was touched on briefly in the question above, but we will cover it in a bit more depth in this section.

Most cameras have two ways of transferring images to the computer-a cable connection or some form of removable storage.

The standard serial connection is quite slow, and has a speed of 115 kbits/sec. A USB cable connection is much faster, and has a speed of 1.5Mbytes/sec.

If the images are stored on floppy diskettes as in the Sony Mavica series, then importing the pictures into the computer is as simple as inserting the diskette into the computer's floppy drive.

Finally, if some form of flash memory is used, then the flash cards can be used in conjunction with either a PC-card adapter (which makes it fit directly into a PC-card slot such as is found on nearly all laptops) or a card reader that attaches to the computer using USB or SCSI.

Of all these options, the PC-card adapter and the SCSI card reader are by far the fastest.

Subject: [3-8] What sort of batteries should I use in my digital camera?

(2000/01/25)

Digital cameras consume a lot of power. If you only use standard "one use" alkaline batteries then you'll spend a lot of time buying new batteries. The most cost effective batteries are rechargeable nickel metal hydride (NiMH) batteries. If these are unavailable then NiCADs are acceptable. There are various recommended charging times for the batteries (usually printed on the battery casing). The more modern chargers are able to turn themselves off at the right time but otherwise you need to remember to turn the charger off yourself. Even rechargeable batteries do not last forever but with proper charging, discharging and reconditioning they may last for years.

Subject: [3-9] What's "red eye" and how do I get rid of it?

(2000/01/25)

"Red eye" is a common finding in photographs taken with flash photography. It occurs when a subject in a dark environment is suddenly exposed to a direct (flash) bright light. Normally, in a dark environment the pupil of the eye is dilated to let more light be exposed to the retinal photoreceptors (at the back of the eye) to maximize visual information. In a bright environment the pupil is constricted to reduce the amount of light so that the retinal photoreceptors are not overwhelmed. You can observe this phenomenon by shining a flashlight into someone's eye and seeing the pupil constrict. If a bright light (i.e. flash) is triggered before the pupil has had time to constrict then the light will reflect off the back of the retina and can be recorded by the camera. Because the retina is richly supplied by blood vessels the reflected light will be red. Our normal experience is that the pupil is black and thus this reflected red light looks strange. There are several ways of reducing/eliminating "red eye" in di gital photos. The techniques used before the photo is manipulated in software are:

- Taking the photograph in bright ambient light. ie studio lighting
- Using "off the camera flash". This works by moving the path of the directly reflected light beam away from the lens of the camera.
- Asking the subject not to look directly into the camera as the photo is being taken. This has the same effect as moving the path of the directly reflected beam.
- Using "red eye reduction" mode on the camera. This mode reduces "red eye" by using a "pre flash light" to constrict the pupil before the actual intense flash and photo occur.

The techniques vary in effectiveness. "Red eye reduction" mode is probably the least effective and cannot be relied upon to eliminate red eye.

Fortunately red eye can be eliminated by software manipulation of photographs and all photographers who take flash photographs of humans and animals should be familiar with the techniques. The tools, and their ease of use, vary from package to package.

Subject: [3-10] What is this Super CCD thing I heard about?

(2000/01/19)

Fuji has announced an improved CCD that they claim offers the potential for improved image quality at cheaper cost. They have announced two cameras based on it, however it appears that both cameras are using very high levels of interpolation. Sharpness appears to have suffered due to the high interpolation levels they have chosen to use.

Subject: [3-11] How do digital cameras stack up to 35mm?

(2000/02/07)

One accepted scientific method for measuring image resolution is to use line pairs per millimeter, abbreviated lp/mm. A test target with alternating black and white lines of equal widths and spacings is photographed, and then the image is analyzed to determine how many lp/mm may be cleanly resolved. In the 35mm case, the film itself is analyzed, in the digicam case, the resulting image file is analyzed.

A decent point and shoot 35mm camera can do around 40-50 lp/mm on 100 speed film in the center of the 35mm frame (lower towards the edges); a high quality lens, around 90+ lp/mm. A good film (Fuji Superia 100 as an example) when shooting a high contrast resolution chart, has a resolution of about 125 lp/mm, so the limiting factor will usually be the lens.

Thus, for 35mm film taken with a basic P/S camera, you get: 50 lp/mm * 2 pixels/lp = 100 pixels per millimeter. 100 pixels/mm * 36mm (width of 35mm frame) = 3600 pixels (ie. pixels in digital terms), and 2400 pixels height-wise.

2400x3600 = 8.64 MP to approximate a decent 35mm P/S image.

For 35mm film taken with a high-quality lens (eg. Leica, T*): 100 lp/mm * 2 pixels/lp = 200 pixels per millimeter. 200 pixels/mm * 36mm (or 24mm) =

4800x7200 = 34.56 MP to approximate a high-quality camera image.

Naturally, this assumes that the resolving capability of a digital camera is such that it can cleanly resolve a line of that width accurately.

Also, it does not take into account that film is analog and actually has higher information recording capabilities -- ie. if a line is smaller than a digital camera's CCD can pickup/sense, it isn't recorded - but with film, it is, even though it is recorded as a smudge and cannot be cleanly resolved.

Chromatic aberrations and other lens defects are also not considered (they cause the halo effect often seen in digital cameras - mismatched color registration in pixels).

At the current rate of digital camera development, we should reach the 8.64 MP level of consumer level cameras in a year to a year and a half. The 34.56 MP level should be reached within three years, assuming we've got flash cards big enough to hold these images and the patience to download them to our PCs.

For more information on lens resolution, check out: http://photo.net/photo/optics/lensFAQ.html
http://photo.net/photo/optics/lensTutorial.html

Subject: [3-12] Can I get SLR digital cameras?

(2000/11/23)

Certainly, if you are willing to pay the price. There have been a number of Kodak cameras made with Canon and Nikon bodies that have been adapted for digital use. These take the normal Canon and Nikon lenses. Nikon has the D1, which also takes the standard Nikon lenses. Minolta has the RD-3000 which can accept their Vectis series of lenses (which were designed originally for their APS SLR and are physically smaller and lighter than their 35mm lenses). Canon has the relatively new D30, which takes their 35mm lenses, and Contax has announced a forthcoming digital SLR as well. These cameras range from US$3000 and up. Olympus has chosen a slightly different route with the E-10, an SLR camera with a non-removable lens. This solves problems with getting dust on the image sensor, but means that attaching wide-angle and telephoto lenses become more difficult.

Subject: [3-13] What about this digital film cartridge I keep hearing about?

(2000/04/16)

For a long time now, a company called Imagek has been promoting what they are now calling their E-film. It is basically a canister/sensor that would drop into a 35mm camera and store images. They claim 1.3 megapixel, with storage in the canister for 24 images. Since they have been talking about it for so long, I'll believe it when I see it.

Many consider this next to useless, due to its high price, low resolution, and the lack of the immediate feedback which many consider to be one of the major driving forces of digital imaging.

Subject: [3-14] What other kinds of digital cameras can I get?

(2000/01/19)

It is possible to get digital backs for medium format cameras. These backs can be either single-shot (Phase One LightPhase) or scanning (Phase One PowerPhase FX). Generally speaking, these produce very high image quality at exorbitant cost. They have no onboard memory, and so must be tethered to a computer using a firewire connection. Image capture rates vary from an image every 1.5 seconds for the single-shot, up to an image ever minute and a half for the scanning back at maximum resolution.

Subject: [3-15] Who makes digicams?

(2000/01/19)

See section [8-1] for a list of digital camera manufacturers.

Subject: [4] In the computer

Subject: [4-1] Okay, its in the computer. What do I do with it now?

(2000/01/22)

Anything you want! The most common things are a) edit it to make it better/different, b) put it up on the web, c) email it to friends/relatives, d) include it in a presentation, e) print it out.

Of these, "a" and "e" are probably the most interesting. Editing allows for a huge amount of flexibility in what the final product looks like. This is one of the great things about digital images-the ease with which they can be modified. Don't like the color balance? Adjust it to your liking. Not enough contrast? Boost it a bit. Image too dark? Lighten the whole thing up. The range of effects which can be performed on your image is literally limited only by your imagination and skill.

Once the image has been tweaked to your satisfaction, printing it out is at once the easiest way and the hardest way to show it to someone else. I say that it is the easiest way because you don't need to take a laptop, or a projector, or haul them into your computer room-you can simply hand them a print. At the same time, however, it can be very tricky to get the output from the printer to match the image on your screen. See section [6] for more on this.

Subject: [4-2] What do I use for editing?

(2000/01/22)

Well, you need a computer and some software.

The computer can be just about anything, but consider the images that you will be working with. Images from digicams are up to about 12MB in size (the file size may be much smaller, but this is the amount of space that it takes up in memory for editing). On the other end of the spectrum, a full resolution 48-bit scan of a 35mm negative using 4000dpi scanner can be as large as 120MB. When you consider that higher-end editing software (with multiple undo and layers) can easily take up RAM equal to 10x the nominal size of the image, you can see that a machine able to usefully edit these monster files could easily use a gigabyte of RAM. At the lower end, 32 or 64MB should be sufficient, although more is of course better.

Microsoft Picture-It, Adobe PhotoDeluxe, and other such "friendly" editing software often comes bundled with consumer hardware. While they may be cute for a while, most people soon tire of the software assuming that the user is clueless and want something with a little more power. The most common serious editing software would be a dedicated image editor like Jasc Paint Shop Pro, Corel Photo Paint, or Adobe Photoshop. A full-featured free alternative to these would be the GIMP, while ImageMagick offers some interesting command-line based utilities, also free. These last two come with source code, in case you feel like adding new functionality. They were also both originally designed for Unix/Linux environments, but have been ported to Windows.

Subject: [4-3] How many pixels do I need?

(2000/01/22)

That depends on what you're doing. If you're only going to be displaying to the screen, then you'll only be able to show however many pixels your screen (or the screen of the person viewing it) can actually display. For most people this will be in the 1024x768 range, although 1280x1024 is becoming more common as 17" monitors come down in price. At the very high end, there are monitors capable of displaying 2048x1536 pixels. In any of these cases, the final image doesn't need to be any bigger than that.

For posting to the web, bear in mind that most people are still on dial-up telephone connections and don't want to wait for minutes for your page to download. Keep images in web pages and email attachments down to 640x480, unless you have a particular reason to send a larger one. Also, this will ensure that people on smaller monitors will have no trouble viewing the image.

Printing to a paper image requires the most pixels-assuming that you have a photo-quality printer, you want to end up with about 300ppi being sent to it. Thus, if you want to print out an 8x10 image, you would want the digital image to be (8*300)x(10*300), or 2400x3000 pixels in size. This is realistically only achievable by scanning a print on a flatbed, or using a film scanner at high resolution. Current digicams cannot give this many pixels at present. It is possible to print the image from a digicam to this size, but it will not be as sharp and detailed as a scan from a negative of the same subject.

Subject: [4-4] What is compression and why would I want it?

(2000/01/22)

Compression is when, instead of saving the actual information contained in the image file, you save information about that image information. Imagine if you took a picture of 2000x3000 pixels that was completely white. You could save the uncompressed image (at a file size of 18MB), or you could save a file that just said "there are 6 million pixels that are all white" (at a file size of under 1KB). This is a crude example of what image compression does.

The reason for compression is rather obvious-which would you rather download, the 18MB file or the 1KB file? Now of course in real life the difference isn't quite that striking, but it is still quite large.

Subject: [4-5] Is there anything bad about compression?

(2000/11/23)

When you receive the image, you have to decompress it. This takes CPU time. If you have a slower CPU but a very fast internet connection it can actually be faster to transfer the uncompressed image rather than to transfer the smaller file and decompress the image. For storing files on your own hard drive, it is generally faster to read in a larger uncompressed image than it is to read in a smaller image and decompress it. This of course varies depending on the speed of the CPU and hard drive and the size of the image.

Aside from this, most compression schemes will throw away some information to compress the image to a smaller size. They are pretty smart about what they throw out (most of it wouldn't be visible to a person anyway), but they are still throwing out information. This is known as lossy compression, of which the commonly used JPEG is a form.

Subject: [4-6] What is the difference between lossy and lossless compression?

(2000/11/23)

Lossy compression has already been mentioned. It tries to compress to a smaller size by throwing out information that it feels you probably wouldn't have noticed anyways. An example of this is JPEG. As you compress the file smaller and smaller, the artifacts (the differences between the compressed image and the original) caused by throwing out this information become more and more noticeable.

Lossless compression uses similar methods as those used to make the popular .zip file to compress the image without throwing information out. These give better image quality at the cost of a larger file size. Because they don't throw out any information, they can't compress as small as the lossy compression. Examples of lossless compression are the GIF, LZW-compressed TIFF, and PNG image formats.

Subject: [4-7] What are the main image file formats and when would I use them?

Subject: [4-7-1] Lossy Formats

Subject: [4-7-1-1] JPEG

(2000/01/22)

This is probably the single most commonly used image file format. It uses some fairly sophisticated methods to encode information about the image, and can compress the image down to a small fraction of its original size with essentially no perceptual differences. The quality of a JPEG is adjustable-when compressing you can trade image quality for size. This allows for very high compression rates, but at the cost of having lousy image quality. At its higher quality settings, JPEG can give excellent results.

JPEG should not be used if there is text or lines of high contrast on the image, as it will cause visible artifacts in the compressed image.

Most digicams use JPEG as their standard image format, generally with two or three different compression modes, which allows the user to trade file size for image quality.

For those interested in writing their own software, an open-source JPEG library is available. It is called libJPEG, and is available at

Subject: [4-7-1-2] JPEG2000

(2000/01/22)

JPEG2000 is the successor to JPEG. It uses a different encoding scheme that allows it to give better results for the same file size, or equivalent results at much reduced file size. Designed by the same people who designed the JPEG standard, it will allow for a different form of compression for text and graphics in a single image, which has the potential for much improved image quality.

JPEG2000 is not yet common, although I expect it to become the standard within the next year or two.

Subject: [4-7-1-3] FlashPix

(2000/01/22)

FlashPix is an interesting image format for web use. It allows the person setting up the web page to make a very high resolution image available, but people downloading it can select what size of image they want to see-anywhere from a small thumbnail all the way up to the entire thing.

However, FlashPix requires additional support in the web browser by way of a plugin, which can be annoying if you require someone to get the plugin before visiting your site.

Subject: [4-7-1-4] FIF

(2000/01/22)

FIF stands for Fractal Interchange Format. There was a brief period where FIF looked very promising, and many thought it might take over as the format of choice for web images. However, converting an image to FIF format took quite a bit of time, which I suspect was one of the factors that led to it being generally ignored in favor of JPEG.

FIF and the other fractal-based image formats still have a niche market however. Because of the way that they are encoded, it is possible to enlarge a fractally encoded image to larger than the original, and it will generally look better than simple interpolation would give.

This can be useful in making large banners or billboards.

Subject: [4-7-2] Lossless Formats

Subject: [4-7-2-1] GIF

(2000/01/22)

One of the original web standard image file formats, GIF is dying out due to Unisys' purchase of the patent rights and subsequent moves to extract payment from anyone writing software to read or write this image format. GIF is generally used with files that have 256 or fewer colors, and allows pixels to be defined as transparent, which is useful in webpages.

Subject: [4-7-2-2] TIFF

(2000/01/22)

TIFF is probably the most common uncompressed or losslessly compressed image formats. TIFF files allow for storage of many different types of image, from 1-bit images compressed the same way that facsimiles are, all the way to 48-bit RGB images and higher. Image sizes can be up to 4GB or so, which makes TIFF useful in certain specialized fields such as remote sensing.

Uncompressed TIFF files are very large, but are very simple in terms of the organization of the file. This allows for very fast reading and writing of the image file.

Certain digicams are capable of storing TIFF images.

Finally, for those of you wanting to do your own image editing, there is an open-source TIFF library available at http://www.libtiff.org

Subject: [4-7-2-3] PNG

(2000/01/22)

PNG was designed from the ground up to take over for GIF as the perfect web format. It uses lossless compression, and with the same original it will generally give a smaller file size than GIF will. It allows for 256 levels of transparency, from full opaque to fully transparent. Information about the image (such as gamma) is stored in the image itself, which allows the viewing program to ensure that you see exactly the same thing that the artist saw.

PNG is not limited to 256 colors, and can be used in place of TIFF, as the images do not lose any quality. For large images, however, it may be faster to save as TIFF format to avoid the time taken to decompress the PNG file.

It should be noted that PNG support has only recently been integrated into the browser, with IE providing essentially full support, and Netscape providing somewhat broken support. The upcoming Mozilla browser fully supports PNG however.

Like JPEG and TIFF, there is an open-source library that can read and write PNG files if you wish to write your own image editing software.

Subject: [4-7-2-4] PSD

(2000/01/22)

PSD is the native format of Adobe Photoshop. It is basically the same as a TIFF file, with different specifics in the layout. Other graphics programs are able to read it, but not all of them can make sense of all the information contained in the PSD file.

Subject: [4-7-2-5] RAW

(2000/11/23)

There are actually two different types of RAW image. The first type is the standard, and is simply the raw image data with no information about the size of the file or how many colors it has-the user must interpret it for the program.

The second type of RAW file (also known as NEF for the Nikon cameras that use it) is written by some Canon digicams, as well as by higher-end Nikon and Olympus cameras. If you look back at how a digicam works, you will remember that each pixel in the CCD only senses one of the three colors, and the other two are then interpolated. In a digicam RAW image, it only stores that single piece of data for each pixel. The format is uncompressed, but since it is only storing the single piece of data, it is a third the size of the equivalent TIFF file, while still keeping all the information that the camera measured. At some point after it's been sent to the computer, however, you will need to run a special program to convert the RAW image to a format more easily understood by all the other editing software.

Subject: [4-7-3] Other Formats

(2000/04/16)

There has recently been some discussion over a program called Genuine Fractals. The program saves the original image as a fractally compressed image (something like FIF) and allows you to specify the desired size of the image when you open it back up.

The general consensus is that the program will not give as good results as an image originally made in the larger size, but if you give it a good image to begin with, it is possible to use it to make better enlargements than would be achieved by simply resampling the image normally. It seems as though the fractals encode edges better, so the enlarged images appear sharper, even though there is no more real information present.

Subject: [4-8] Does opening a JPEG image cause it to degrade?

(2000/04/16)

Not unless your image editing or display software is extremely poorly behaved. It is only when the file is decompressed and then recompressed and saved that the image may lose some quality. Simply reading the file multiple times has no effect until you save the image back to the original file name. Even then, a couple of decode/encode cycles will have very little effect on image quality. It's only when you are doing many cycles of decode and encode on a single image that it actually can cause noticeable artifacts.

To put the whole thing in perspective, I did a test. I took an image and saved it in photoshop as a JPG at one of two quality levels, 10 and 12 (out of 12). I then opened it up and saved it under a different name, at the same quality level. I repeated this 10 times, opening up the most recently saved image and saving it under a different filename. The results are below. The left column is the number of intensity levels of difference between the final image and the original, while the other two colums are the % of pixels at that difference or less.

```
Intensity       percentile      percentile
difference      quality 10/12   quality 12/12
0               75.93           56.57 <-- interesting result here
1               85.05           85.68
2               91.55           94.5
3               97.98           97.91
4               98.98           99.5
5               99.89           99.95
```

In the 10/12 quality, the most a single pixel was out was 10 intensity levels (out of 255), and there were 448 pixels out that much (out of an image with 1.46 million pixels). At the 12/12 quality, the worst was 7 levels difference, with 46 pixels out by that much. I should add as a caveat that while the intricate areas look extremely close, the large smooth colour gradients were the worst affected, and the difference is definately visible in those areas

Subject: [4-9] How do I store the images for future use?

(2000/01/22) Three are two viable options-the hard drive, or some form of removable storage. This would include floppies (which are notoriously unreliable and I would recommend be avoided), zip and jaz disks, and the like, and recordable CDROM. For large amounts of information, I would recommend the recordable CDROM. Prices on the drives have come down substantially in the last two years, and blank media costs about $1.50 or less for 650MB of storage space. Since DVD drives are backwards compatible with CDs, any CDs that you put together now should be readable for quite a few years to come.

Subject: [5] Printers

Subject: [5-1] How do printers work?

(2000/01/24) There are three main types of consumer level printers, laser, ink jet, and dye sublimation. There are also professional level printers that use LEDs to directly expose paper which is then chemically processed as though it were a normal photograph.

Subject: [5-1-1] Laser

(2000/01/24)

Laser printers use the light of a laser to sensitize a drum, causing the drum to either gain or lose electric charge at that point. The drum then picks up powdered ink in the pattern of the image, and that is transferred to the paper. Finally, the ink is thermally fused to the

paper, giving the end result.

Subject: [5-1-2] Dye Sublimation

(2000/01/24)

Dye sublimation printers should really be more accurately known as dye diffusion printers, as all but the most high end do not really sublimate the dye, but rather diffuse it onto the paper. This type of printer takes a roll or ribbon of dye (generally three colors and black). Each color of dye is placed over the image, and then a thermal print head is used to transfer the dye to the paper. The advantage to this is that the heat level can be varied, thus giving different levels of color intensity directly, rather than having to use dithering as ink-jet printers do. However, the necessity for the transfer rolls or ribbons means that a lot of the dye is wasted (adding to the expense). Dye sub printers are capable of very high quality results, but are being pressed closely in quality by the ink jets.

Subject: [5-1-3] Ink Jet

(2000/01/24)

Ink jet printers are the most common form of printers used for photographic purposes. The ink is stored in liquid form in cartridges (usually 4 or 6 colors for photographic printers, in 1 or 2 cartridges). The ink is literally squirted out in tiny droplets onto the paper. This squirting can be done by direct mechanical processes or using heat to vaporize a tiny amount of ink to propel the droplet out of the nozzle. The best current printers have a drop size of 3 picolitres. Ink jet prints have the potential to be quite good, but in gradually shaded light areas it is often possible to see the individual ink dots. Due to their relative cheapness, ink jets are by far the most common form of photo printer.

Subject: [5-2] What resolution can the human eye see?

(2000/04/16)

The human eye's resolution is a function of brightness and contrast. It was studied in detail in the book:

Blackwell, H.R. (1946) Contrast thresholds of the Human Eye J. Optical Society of America, vol36, p624-643.

Blackwell shows the smallest resolvable detail is 0.7 arc-minute (valid for young people [age in their 20s] with 20/20 eyesight). This value gets worse as you age, but it is difficult to find scientific numbers for how much. He used round images in the tests.

0.7 arc-minute at 10 inches is 0.002 inches, implying 500 spots/inch can be resolved, needing (minimum 2 pixels/spot) = 1000 pixels/inch.

As you can see, the human eye is quite good--great dynamic range too! This explains why young people can often tell the text output of a 300 dpi laser printer from a 600 dpi laser printer.

Subject: [5-3] Okay, then what resolution is required for photographic quality?

(2000/04/16)

The general consensus is that 300dpi of effective resolution is sufficient for "photographic quality". Of course, if you peer closely at the output you will be able to determine that it is not a true photograph even at 300dpi, but that close an inspection is very rare. 300dpi gives very good images that the average person will not be able to tell from a chemical print.

Subject: [5-4] But my printer resolution is way higher than that!

(2000/01/24)

The rated resolution of printers is given in dpi, or dots per inch. However, those dots are of a single color, and in all but the dye-sub case those dots are of a fixed intensity. Because of this, it takes multiple dots blended together to produce a real "dot" of a given color. Thus, the effective dpi is generally less than the rated dpi.

The original HP Photosmart printer is somewhat of an exception to this. Because of the type of ink used, it could layer its inks on top of each other, producing very close to an effective 300dpi even though it's true rating was only 300dpi.

In the case of dye-sub printers, the fact that they can overlay their inks and also vary the intensity of each color gives them an effective dpi equivalent to their rated dpi.

Subject: [5-5] How do image pixels correspond to ink dots?

(2000/01/24)

Early printers had a direct correlation between the input and the output ink dots. Current printers use sophisticated algorithms (error diffusion is one) to convert the input image pixels to output ink dots. Because of this, there is no longer a direct relation from one to the other. Rather, it depends on image content.

Subject: [5-6] How big can I print?

(2000/01/24)

Most consumer printers will do 8"x10", some will do legal and banner size as well. The Epson Stylus Photo EX, Stylus Photo 1200, and Stylus Photo 1270 can do up to 13"x44".

Subject: [5-7] How do I get information to the printer?

(2000/01/24)

There are five methods of sending information to the printer.

The first and most common is the basic printer cable. This attaches your printer to the parallel port on the computer, and can transmit up to 3Mbyte/sec.

The second method is the USB cable. This attaches the printer to the USB port of the computer and can transmit up to 1.5Mbyte/sec.

The third method is by using Ethernet. Generally only used for high-performance business printers (read extremely expensive), this allows for 100Mbit/sec data transfer speeds.

The fourth method is using the IrDA port. I don't know of any really high-end printers that use this, but some color printers designed for use with laptops do. Speeds are variable, but generally slow.

Finally, the fifth method is found on the new HP PhotoSmart P1100 printer, and allows users to plug flash memory cards directly into the printer. Pictures can be selected and printed without using the computer at all. (Although this also means that you can't do any editing before printing.)

Subject: [5-8] Who are the main printer manufacturers?

(2000/01/24)

See section [8-3] for a list of the main printer manufacturers.

Subject: [5-9] Which is the best printer?

(2000/01/24)

Again, this is a difficult question, as it depends on what you need in a printer. The Epson Photo Stylus 1270 can print larger than the other consumer printers, but the HP P1100 gives very good output and can print directly from flash memory cards. The Alps dye-sub printers give excellent quality output, but at an increased cost per page. Most people interested in digital imaging end up getting one of those three brands, although there are certainly others to consider.

Subject: [6] Colour Management

Subject: [6-1] Why doesn't the image on the screen match the real object?

(2000/01/24)

There are three reasons; your scanner/camera, your monitor, and your software.

The scanner/camera will not be perfect in turning the image into digital form. The human eye has a lot of adaptability that electronic devices do not have. This leads to bad white balance, incorrect exposure, and other such difficulties. High contrast scenes may simply be impossible to accurately sample with consumer equipment.

If the digital image is correct, your monitor may be adjusted incorrectly. Brightness and contrast controls, as well as the color temperature setting of your monitor, can make a huge difference in what the image on the screen looks like. I have the best results with

contrast turned way up and brightness turned way down, but this should be calibrated using an image designed for the purpose.

Finally, if the digital image is correct and your monitor is set properly, your software may be messing things up. Make sure that if your software has color management settings, you are using them properly. Improper settings will cause problems.

Subject: [6-2] Why doesn't the image from the printer match the image on the screen?

(2000/01/24)

There are again three possibilities; the monitor, the software, and the printer.

If the image doesn't match the image on the screen, but it does match the original, then you have a problem with either your monitor or your software.

If the screen image matches the original, then it is a problem with either the software or the printer. If the software has color management settings for the printer, you need to use them to adjust the output until it matches what you see on the screen and the original item.

Subject: [6-3] Why do people complain my images are too dark (or too light)?

(2000/01/24)

If your computer is set up differently than theirs, then they will not see exactly the same image that you do. In a case like this, either the brightness/contrast settings of the monitor are at fault, or they are using a different gamma setting than you.

Subject: [6-4] Why do images on the web look too dark (or too light)?

(2000/01/24)

Most images on the web are set up for a standard windows PC gamma value. People using Apple computers may find that they need to adjust the images before they will look right. If someone using a Mac puts up images on the web, PC users may find that the don't look quite right and will also need to adjust the images or their gamma settings if the video card allows for it.

Subject: [6-5] Why do images on the web look too red (or too blue)?

(2000/01/24)

If the person who created the images was using a different monitor color temperature than you, then the images can look too red (or blue). If the image appears too blue, try going to a lower color temperature. If the image is too red, try adjusting your monitor to a higher color temperature. (Note that not all monitors have this setting-if you don't you might be able to make some adjustments in the video card drivers, otherwise you will simply have to live with it.)

Subject: [7] Digital vs. Analog

Subject: [7-1] When will digital be as good as 35mm?

(2000/01/24)

This is a common question, but doesn't have a single answer. In terms of sheer resolution, digital has a long way to go. Recent tests have shown that 6000dpi extracts more information than 4000dpi from a good 35mm image. A full size 35mm image scanned at 6000dpi gives in excess of 48 million pixels. Comparing this to current realistically priced digital cameras at 2.7 million pixels, and you can see that there is a ways to go yet.

That being said, however, if all you want is to produce 4"x6" images, and maybe the odd 5"x7", then digital has essentially matched film already.

Subject: [7-2] When will digital be as good as medium format?

(2000/01/24)

There are already digital back for medium format cameras. However, they are nowhere near the resolution of film. Look at the resolution comparison for 35mm, and then extrapolate....digital has a LONG way to go before it equals medium format for sheer image detail.

Subject: [7-3] Is there anywhere that digital is better than film?

(2000/01/24)

It is possible for digital images to have better light sensitivity than film, however current CCD technology is such that to reduce the dark current noise these arrays have to be cooled. Astronomists have largely converted to CCDs due to the increased sensitivity and greater color accuracy as compared to film.

Subject: [7-3-1] How do they get such good results?

(2000/01/24)

The better results are due to really expensive CCD arrays, and the fact that they can cool them down to extremely cold temperatures, thus increasing the performance of the CCD. Neither of these are practical options for the consumer digital camera, but technology increases will help boost performance as time goes on.

Subject: [8] Hardware

Subject: [8-1] Digicams

Subject: [8-1-1] Which digicam should I buy?

Subject: [8-1-1-1] Nikon

(2000/02/08)

At their high end, the D-1 stands out. With support for virtually the entire range of Nikon lenses and accessories, the D-1 is a tempting prospect to Nikon 35mm photographers who don't want to buy a whole new set of lenses for an SLR digicam. However, at $5000 it isn't cheap.

The Nikon Coolpix 950 is one of the most often-mentioned digital cameras. The optics are first rate, but there have been complaints about the placement of the tripod socket and the flimsiness of the memory card door. These complaints appear to have been addressed in the new 990, announced at PMA 2000.

Subject: [8-1-1-2] Sony

(2000/04/16)

Often maligned for their floppy storage, the Sony Mavica FD-91 offers some of the highest levels of optical zoom it is possible to get in a digicam (14x). It also offers image stabilization, to allow for sharp shots when zoomed in.

The new CD-1000 offers much more storage as it writes to mini CD-R discs. It also offers a high level of optical zoom.

The F505 has the distinction of not having an optical viewfinder, however it does have a very nice LCD display and an excellent Zeiss lens. Image quality is very good.

Subject: [8-1-1-3] Hewlett-Packard (HP)

Subject: [8-1-1-4] Minolta

Subject: [8-1-1-5] Canon

(2000/11/23)

The Canon D30 seems to be holding its own as a digital SLR. One of the first higher-end cameras to use a CMOS sensor rather than a CCD, the D30 shows excellent shadow behaviour, especially in long exposures.

Subject: [8-1-1-6] Olympus

(2000/11/23)

The Camedia E-10 is a very interesting and promising camera. With much the feel of an SLR and a manual zoom ring, this camera has a non-interchangeable lens. This solves the problem of dust on the image sensor at the cost of some flexibility. However, wide-angle and telephoto attachements fit onto the front of the lens to change the zoom range. Olympus claims that the main lens is the best digital camera lens in existence, as it is specifically designed and matched to the image sensor being used in the camera.

Subject: [8-1-2] Which brand of flash memory should I buy?

Subject: [8-2] Scanners

Subject: [8-2-1] Which scanner should I buy?

Subject: [8-2-1-1] Nikon

(2000/02/08)

Nikon sells the excellent LS-2000 scanner, which is capable of 2700ppi and 12 bits per channel, and has a dynamic range of 3.6. They also sell the LS-30, which is 10 bits per channel and a dynamic range of 3.0. Both of these scanners support a feature called Digital Ice, which uses an infrared sensor to help fix dust and scratches on the image.

Subject: [8-2-1-2] Polaroid

(2000/02/08)

The SprintScan 4000 is one of the highest resolution consumer film scanners available, with 4000dpi and a dynamic range of 3.4. However, tests don't seem to show much difference between it and the LS-2000 in terms of dynamic range.

Subject: [8-2-1-3] Hewlett-Packard (HP)

(2000/02/08)

HP offers the only dedicated photographic film/slide scanner that can also do prints. However, because the scanning mechanism moves the film/image past the scan heads rather than the other way around, image quality suffers very slightly. HP's software support is also known to be poor. The hardware, however, is quite good, if not up to the level of the Nikon offerings.

Subject: [8-2-1-4] Minolta

(2000/04/16)

Minolta makes excellent scanners, some of which are in direct competition with the Nikon offerings. Their newest scanner, the Elite, has a resolution of 2820dpi, a dynamic range of 3.6, and supports the same Digital ICE technology as the Nikon scanners. The Multi is one of the few film scanners that can scan medium format, although the scanner resolution is sharply decreased in this mode. Absolute number of pixels achieved in this mode is similar to that achievable from 35mm.

Subject: [8-2-1-5] Canon

(2000/04/16)

The Canoscan film scanner just doesn't have the same reputation as the others. Although made by a camera manufacturer, it just doesn't seem to give the same class of results.

Subject: [8-2-1-6] Kodak

(2000/11/23)

Kodak has a very intriguing scanner newly released, called the RFS3600. They claim it has ICC profiles available, and has presets available for scanning Kodak film-which should give it an advantage, as you would expect Kodak to know how to scan their own film properly.

Subject: [8-2-1-7] IBM

Subject: [8-2-1-8] Microtek

(2000/02/08)

Microtek offers a scanner that is essentially identical to the Polaroid SprintScan 4000, although the software that comes with it is somewhat different. Performance should be similar.

Subject: [8-2-1-9] Umax

Subject: [8-3] Printers

Subject: [8-3-1] Which printer should I buy?

Subject: [8-3-1-1] Epson

(2000/11/23)

Recently Epson added two new printers to its line, the 870 and the 1270. These printers are getting excellent reviews on their image quality, and the output when using their matte heavyweight paper is rated at 25 yrs.

However, they seem to go through ink relatively quickly, and the cartridges are not refillable. Epson has added a special microchip to the cartridges that ensures that the printers will not work with cartridges by anyone else, so you're basically locked into buying Epson inks for the life of the printer.

There have been some complaints made about pictures printed on the glossy paper turning orange under certain conditions. This has not been widely publicized, but Epson has gone so far as to buy back printers and unused paper from unsatisfied customers.

Subject: [8-3-1-2] Hewlett-Packard (HP)

(2000/04/16)

The Photosmart series of printers shares the print engine with the 970-series printer, but have slots for flash cards to allow for printing directly from the card. They can also be used to upload images from the card to the printer, but the transfer speed is not very fast.

Image quality is excellent, although possibly not up to the standards of the new Epsons. Output life is rated at up to 5 yrs.

Subject: [8-3-1-3] Canon

Subject: [8-3-1-4] Alps

Subject: [8-3-1-5] Fuji

(2000/04/16)

Not commonly seen in the consumer realm, the professional Fuji printers are very good indeed, some of them actually exposing light sensitive paper which is then developed in a chemical bath. Output is essentially indistinguishable from an analog photograph.

Subject: [8-4] What kind of computer is recommended?

Subject: [8-4-1] How fast a CPU do I need?

(2000/01/24)

Well, the faster the better, of course. Generally speaking, however, it makes little sense to buy the absolute fastest processor for digital imaging. It usually makes more sense to get the second or third fastest and put the money saved towards additional RAM.

Subject: [8-4-2] How much memory do I need?

(2000/01/24)

As much as you can afford, and then some.

Seriously, it depends on what type of file you are working with. If you are dealing with 1600x1200 pixel digicam snaps, then you can make do with 32 or 64MB of RAM (the larger amount is highly recommended). If you are dealing with high resolution scans from negatives or slides, then it is not unreasonable to have hundreds of megabytes of RAM. When you consider that a high resolution (4000dpi) scan of a full frame 35mm negative can take up 120MB, even a gigabyte of RAM is not completely unreasonable.

Subject: [8-4-3] How much storage space do I need?

(2000/01/24)

Again, it depends on what kind of file you are working with. If you are scanning negatives at high resolution, then many gigabytes of storage may be required. If you are using a digicam that produces 640x480 JPEG files, then the storage requirements are much smaller.

In either case, some form of removable storage is recommended. CD-writers have dropped substantially in price, and the media is now quite cheap. I would recommend them as storage for digital images. At $1 or so for 650MB of space, you can easily afford to make frequent backups.

Subject: [9] Software

Subject: [9-1] Image Editing

Subject: [9-1-1] Adobe - Photoshop

(2000/11/23)

This is essentially the standard against which all other image editing software is measured. It is capable of incredible flexibility, but has a very steep learning curve. Popular for prepress use, it has options that the home user would never use. However, its very popularity ensures that there are many tutorials and books on how to use it that are quite easily located.

As a side note, up until version 5.5 at least (I haven't tested version 6) Photoshop does not actually support true 16-bit per channel images even though they claim to. In reality, they truncate the images to 15-bits per channel. If you want to work with 16-bit per channel images without losing information, don't use Photoshop to do it!

Subject: [9-1-2] Corel - Photo Paint!

Subject: [9-1-3] - Paint Shop Pro

Subject: [9-2] Image Viewing, Thumbnailing, and Organization

Subject: [9-2-1] Cerious - ThumbsPlus

(2000/01/24)

Offers thumbnail views of many different image formats. Automatically scans whatever directory you choose, and stores the information in a central database file (which can become very large as time goes on). ThumbsPlus offers one of the better slideshow modes that I've seen, with keyboard commands for pause, forward, and backwards in addition to standard timer-based advance. The batch mode processing works well, if a bit tricky to get used to at first.

Subject: [9-2-2] Thumber

Subject: [9-2-3] VuePrint

Subject: [9-3] What other useful software is there?

Subject: [9-3-1] ImageMagick

(2000/01/24)

This is more a software library than a single program, and it comes with example programs that run under Xwindow or from the command line. It is very flexible and is very good at what it does. It is entirely open source, which allows you to fix any problems you find if you so desire. You can also use it as the basis for your own image editing software.

Many different file types are supported (including some that I've never seen before), and many operations are possible. The "convert" program is particularly useful for batch processing.

Subject: [9-3-2] VueScan

(2000/11/23)

Very useful for slide scanning, less so for negatives in my experience. I generally shoot Fuji film, so this may be one of the problems. Generally gets the best out of the scanners for slide scanning though, giving extremely good results. Interesting features: supports multipass scanning with the Nikon LS-30, supports the Digital ICE feature of the Minolta Dimage Scan Elite, Nikon LS-30 and LS-2000 (and makes better use of it than the Nikon software does, apparently), and gave better focus with the Polaroid SprintScan 4000 than Polaroid's own software did (although this has since been corrected).

The author, Ed Hamrick, is quick to respond to user issues, and is a knowledgeable presence on the news:rec.photo.digital newsgroup.

Subject: [10] Net Resources and Vendor Lists

Subject: [10-1] Information resources

LENSES:
http://photo.net/photo/optics/lensFAQ.html Good information http://photo.net/photo/optics/lensTutorial.html More good information

FILM:
http://www.fujifilm.co.uk/technical/index.html Information on all their films

DIGICAM WEB SITES
http://www.imaging-resource.com/ARTS/HOWBIG/HOWBIG.HTM Pixels article
http://www.cee.hw.ac.uk/~lachlan/mmhmlectures/stand.htm Compression article
http://www.servtech.com/~dougg/graphics/jpeg.htm#examples JPEG http://www.cliffshade.com General digital imaging information

FORUMS
http://www.steves-digicams.com/webbbs/config.pl ? Steve's Forum

http://www.mavican.nu/cgi-bin/mavica/mavica.pl Mavica Info Exchange
http://cybershot.hypermart.net/ Cybershot forum
http://www.acecam.com/aceforum.html#READ ACE Forum
http://www.photoshopper.com/forum/flash.html Flash Forum
http://www.photoshopper.com/index.html Photoshopper Forum
http://www.dpreview.com Phil Askey
http://www.digitalkamera.de/Info/Default-en.html European News
http://www.dpcorner.com/cgi-bin/share/index.cgi Comer Forum
http://www.imaging-resource.com/FORUM.HTM DC Resource
http://www.dcresource.com/ DCRP
http://forum.s-one.net.sg/forum/20/list.pl Asia

NEWS
http://www.shortcourses.com/buying.htm#Reviews

http://www.steves-digicams.com/diginews.html Steve's Digicams
http://www.dpcorner.com/ Comer
http://www.dcresource.com/index.shtml DC Resource
http://www.eetimes.com/story/OEG19981015S0023
http://www.image-acquire.com Digital Eyes
http://www.imaging-resource.com/NEWS.HTM#anchor5300041 Imaging Resource
http://www.dcresource.com/
TUTORIALS
http://www.sgi.com/grafica/ Digital/photography articles/tutorials
http://www.shortcourses.com/ Dennis Curtin Digital Camera Courses
http://webs.kodak.com/US/en/digital/dlc/ KODAK Digital Learning Center
http://www.nyip.com NY Institute of Photography
http://www.northnet.org/jimbullard/lessons.htm General Photography
http://albums.photopoint.com/j/AlbumIndex?u=10081&a=57018 Photoshop tutorial
http://www.graphicswiz.com/graphicswiz/tutorial.html Graphics
REVIEWS/TESTS
http://www.resellerratings.com/ Reviews of Internet Sellers
http://www.inconference.com/digicam/index.html Reviews
http://www.quiknet.com/~frcn/FramCam.html FRCN REVIEWS/INFO
http://dreamarts.co.jp/magazine/miscall/DC/compair/yakei/index.html Digicam Tests
http://www.epinions.com

FLASH
http://www.cyberramp.net/%7Esrx/flash.html Digi-Slave SLAVE FLASHES
http://focuscamera.com/meters/slavwein.shtml Wein SLAVE FLASHES
DIGICAM OPTICS
http://www.schneideroptics.com Optics/Pixel Size, etc.
http://www.stoegbauer.com/destpages/advntg2.html Digital Photography
http://www.scantips.com/ Scanning

BOOKS
http://www.uwreport.com/wire/revDC/MreDCb.htm http://www.jay-tepper.com/books.html Camera Collecting
http://www.mindspring.com/~todcam/books.htm#Manuals

PHOTO ORGANIZER PROGRAMS

http://www.arcsoft.com/prodpb10.htm PHOTO ORGANIZER
http://www.ebooksys.com/ Photo Album and Thumbs
http://www.cerious.com/index.html ThumbsPlus
http://www.caere.com Photo organizing
http://www.ixla.com Photo organizing
http://www.pictureworks.com/ HotShots Thumbs program

MISC.
http://come.to/digitaldarkroom Digital Darkroom - Scanning, etc. http://www.stillwtr.com/mavica Telescope Adapter
http://www.scopetronix.com Scope adapters, etc.

http://ckcpower.com/ Scopes, etc
http://www.wacom.com/ Graphics Tablets
http://www.inksite.com/media.html PRINTER PAPER
http://www.mediastreet.com/g2.htm Permanent Ink
http://www.hanes2u.com/ Haynes HEAT TRANSFERS
http://www.conde.com/imprint/index.html Conde HEAT TRANSFERS
http://www.lowepro.com/ LOWEPRO CAMERA BAGS
http://home1.swipnet.se/~w-12269/equip/index.htm ACCESSORIES
http://www.ckcpower.com Tele-converter tests
http://www.leica-camera.com/usa/index.htm Leica USA
http://www.italyemb.org/italybbs/index.html Italian Bulletin Board
http://www.silvestricamera.com/intro.htm Italian camera
http://www.craigcamera.com. camera manuals
http://www.sonnetech.com/products/color2.html MONITOR COLOR MATCHING
http://www.quantimage.com/ Quantum Image, technical equipment
http://members.aol.com/jbaumg4178/howto/upload.htm#doit LOADING PICS

http://www.scantips.com Scanning information, worth visiting http://www.cameras.co.uk General photography (digital and otherwise) information

Subject: [10-2] Magazines and other publications

MAGAZINES
http://www.mav-magazine.com/ Mavica Magazine
http://www.zdnet.com/pcmag/news/trends/t981020a.html PC MAGAZINE
http://www.digicamera.com Digital Camera Daily
http://www.peimag.com/ PEI Magazine
http://www.megapixel.net/ DIGITAL MAGAZINE
http://www.journale.com/medialab/index.html MEDIA LAB
http://www.maximumpcmag.com/ Maximum PC
BOOKS
Digital Photography for Dummies. Julie Adair King. IDG Books Worldwide, Inc. 1997. $24.99 list
This book includes a CD with sample image editing programs and other demo programs.
Digital Camera Companion. Ben Sawyer & Ron Pronk. Coriolis Group Books. 1997. $29.99 list. 37
This book includes a CD with sample image editing programs and other demo programs.
Teach Yourself Digital Photography in 14 Days. Carla Rose. Hayden Books. 1997. $39.99 list. 3
Fun with Digital Photography. John Larish (Kodak). Silver Pixel Press. 1996. $9.95 list. 76 p
Computer Photography Handbook. Rob Sheppard. Amherst Media, Inc. 1998. $29.95 list. 120 pages.
Digital Photography Answers! Dave Johnson. Osborne/McGraw-Hill. 1999. $24.99 list. 511 pages.

Digital imaging Dictionary. Sally and Daniel Grotta. McGraw-Hill. 1998. $29.95 list. 363 pages
A Guide to Digital Photography - Theory and Basics. AGFA. Agfa Educational Publishing. 1996. $
Essentials of Digital Photography. Akira Kasai & Russell Sparkman. New Riders Publishing. 1997.
This book includes a CD with sample image editing programs and other demo programs.

Magazines--There are a number of magazines devoted to digital photography or digital imaging. Several are listed below. Film photography magazines such as Popular Photography are also devoting more of their content to digital photography issues.

PC Photo. Werner Publishing Corp. Subscription: PC Photo, Box 56380, Boulder, CO 80323-6380. Bi

Digital Photographer. Miller Magazines, Inc. Subscription: Digital photographer, P.O. Box 677, Mount Morris, IL 61054-7541. Quarterly. $4.99 at newsstand or $9.98 for 4 issues. Digital Camera. Aeon Publishing Group. Subscription: Digital Camera Magazine, P.O. Box 408, Plainview, NY 11803-9801. Bimonthly. $3.95 at newsstand or $18.00 for one year (8 issues). http://www.digicam.com . PEI. PPA Publications & Events, Inc. Subscription: PEI International Tower, 229 Peachtree St NE, Suite 2200, Atlanta, GA 30303. Monthly. $4.00 at newsstand or $20.00 for 12 issues. http://www.peimag.com

Subject: [10-3] Manufacturer and Vendor Websites

(2000/01/24

SONY
http://www.sel.sony.com/SEL/ Sony Electronics http://www.sel.sony.com/SEL/feedback.html Sony Feedback 1-888-449-7669 Mavica Hotline

http://www.ita.sel.sony.com/factory_outlet/ Refurbished cameras
http://www.connact.com/~eaw/minidisc/sony_outlets.html Sony Outlet Stores
http://www.outletbound.com/ Sony outlet stores

MAVICA
http://www.fotos4uscreensavers.com/maviacalinks.htm MAVICA INFO http://MavicaUsers.Org/SonyWebSites.html Sony WEB SITES
http://www.mavican.com/
http://members.tripod.com/~oldnco/MISC/guild.html Mavica Guild

EPSON

http://www.epson.co.nz/index.html Epson
provantage.com. Ink and paper
KODAK
http://www.kodak.com/US/en/nav/digital.shtml KODAK
DEALERS
http://www.arizona-photo1.com/bestpric.htm 15 LOW PRICE DEALERS
http://www.20-20consumer.com/htm/digital_cameras_screen_quality_page78_sub.htm Prices
http://www.savexpress.com/ SAVE EXPRESS
http://www.savexpress.com/AT-savexpresssearch.cgi 550 battery $39
http://www.buysoftware.com/ 550 battery $40
BUYCOMP
http://www.buycomp.com/bc/default.asp? BUYCOMP
714-788-3906 BUYCOMP FAX ORDERS
714-788-3906 BUYCOMP FAX INFO
sales@buycom.com BUYCOMP E-MAIL ORDERS
http://www.buycomp.com/bc/noframes/tracking/tracking.asp Order
Tracking
888-880-1030 BUYCOMP CUSTOMER SERVICE
http://www.dcresource.com/ LOWEST PRICES
http://www.cameraworld.com/ Camera World
http://www.aaacamera.com/sony_dscd770_cybershot.html D770 vendor

Subject: [11] Contributors

(2000/04/16)

The information on 35mm lens and film resolution was used by permission from a post by David Chien.

I've blatently grabbed many of the links and resources in section 10 from a post by Rodger Carter. I can only imagine how much work it was to compile that list.

The overall format and much of the legal section was taken from the CD-Recordable FAQ by Andy McFadden, at http://www.fadden.com/cdrfaq/

The last-modified date of each section is shown below the Subject line. The date format used is YYYY/MM/DD. --
Send mail to chirs@bigfoot.com (Chris Friesen)

news:rec.photo.digital FAQ - http://www.crosswinds.net/~rpdfaq

Fight Net Spam - http://spam.abuse.net/spam/ & news:news.admin.net-abuse.email