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This manual is also available as consolidated pages, for downloading and printing (see the bottom of this page).

Web Multimedia and Animation

Papers

Appendices

Downloading & Printing Options

C/AIM

This style manual developed as an outgrowth of our own World Wide Web (Web) development projects. It reflects our attempts to apply some of the lessons we've learned in twelve years of multimedia software design, graphic interface design, and book design to the new medium of Web pages and site design. There are fine existing Web sites and books that emphasize Hypertext Markup Language (HTML), and others that emphasize commercial and art-oriented Web graphic design. However, few existing resources have attempted to approach Web page and site design as a challenge that combines traditional editorial approaches to documents with graphic design, user interface design, information design, and the technical authoring skills required to optimize the HTML code, graphics, and text within Web pages.

What this manual is not

Our approach to both the HTML language and the general problem of information design in World Wide Web systems is not grounded in the philosophy that drives the development of structured information publishing tools like HTML's parent language, SGML (Standard Generalized Markup Language). The advice here is aimed at the practical concerns of bending and adapting a relatively primitive authoring and layout tool (HTML) to purposes it was never really intended to serve (graphic page design). If you are interested in the larger questions of publishing in highly structured systems that are independent of browser software, operating systems, or typographic restrictions you might want to begin with the World Wide Web Consortium's (W3C) Web site, which lists many technical and historic references related to the development of structured text, and material on the history of the Web.

A note about web browsers

Most of the design advice and technical information contained here on optimizing graphics in Web pages is tailored to recent versions (2.0 or later) of both Netscape Navigator and Microsoft's Internet Explorer. There is little here of benefit to users of text-based Web browsers, as the primary focus of this manual is on graphic page design.

References

HTML Authoring Resources

Microsoft Internet Explorer

Netscape Navigator

World Wide Web Consortium (W3C)

The first step in designing a Web site is to make sure you have defined a set of goals know what is you want to accomplish with your Web site. Without a clear statement of purpose and objectives the project will begin to wander off course and bog down, or may go on past the point of diminishing returns. Careful planning and a clear sense of purpose are the keys to success in building Web sites, particularly if you will be working as part of a team to build the site. Before beginning to build your Web site you should:

- Identify your target audience
- Have a statement of purpose
- Know your main objectives
- Have a concise outline of the information your site will contain.

You should also begin to identify all of the content information and graphic resources you will need to collect or create to achieve the goals you have set for your Web site.

What are your ultimate objectives?
A clear, short statement of objectives should form the foundation of your site design. This is where you expand on the goals in your statement of purpose, and will be the tool you will use to analyze the success of your Web site. For example:

> "We expect the association's Web site to accomplish these goals over the next twelve months:
>
> The Web site will reduce the demands on the central office for routine information on association activities, deadlines, dues and fees, and information on association meetings. We expect that the Web site will also allow us to save a significant amount on postage and processing of routine member correspondence. The Web site will carry all of the content that currently goes into our association's quarterly newsletter, but will also carry more timely information as events warrant. After a year we will poll the membership on the success of the Web site newsletter, and explore the possibility of dropping publication of the paper newsletter."

The statement should go on to list a few more specific financial and other organizational goals the Web site is designed to fulfill, how long the evaluation period will be, and how the success of the site will be evaluated.

Building a Web site is usually an ongoing process, not a

one-time project with static data. Long term editorial management and technical maintenance must be covered in your plans for the site. Without this longer perspective your electronic publication will suffer the same fate as many newsletters an enthusiastic start, but no lasting accomplishments.

Know your audience

The next step in the design process is to identify the potential users of your Web site, so that you can structure the site design to meet their needs and expectations. The knowledge, background, interests, and needs of users will vary from tentative novices who need a careful structured introduction to expert "power users" who may chafe at anything that seems to patronize them or delay their access to information. A well-designed system should be able to accommodate a range of user skills and interests. For example, if the goal of your Web site is to deliver internal corporate information, human resources documents, or other information that used to be published in paper manuals your site will be used by people who will visit many times every day, and also by people who only occasionally refer to the site.

Web surfers

Home pages aimed at browsers should be analogous to magazine covers. The objective is to entice the casual browser with strong graphics and bold statements of content. All the links on your home page should point inward, toward pages within your site. Provide a very clear and concise statement of what is in the site that might interest the reader.

Less than 10% of Web readers ever scroll beyond the top of Web pages.

Novice and occasional users
These users depend on clear structure and easy access to overviews that illustrate how information is arranged within your Web site. Novices tend to be intimidated by complex text menus and may be tentative about delving deep into the site if the home page is not graphically attractive and clearly arranged. According to Sun Microsystems Jakob Nielsen, less than 10% of Web readers ever scroll beyond the top of Web pages. Infrequent users benefit from overview pages, hierarchical maps, and design graphics and icons that help trigger memory about where information is stored within your site. A glossary of technical terms, acronyms, abbreviations, and a listing of "frequently asked questions" can be helpful to first-time or infrequent users of your site.

Expert and frequent users
These users depend on your site to obtain information quickly and accurately. Expert users are very impatient with multiple low-density graphic menus that only offer two to six choices at time. Power users crave stripped-down, fast-loading text menus. Graphic fru-fru drives them nuts. Expert and frequent users generally have very specific goals in mind, and will appreciate detailed text menus, site structure outlines, or comprehensive site indexes that allow fast search and retrieval.

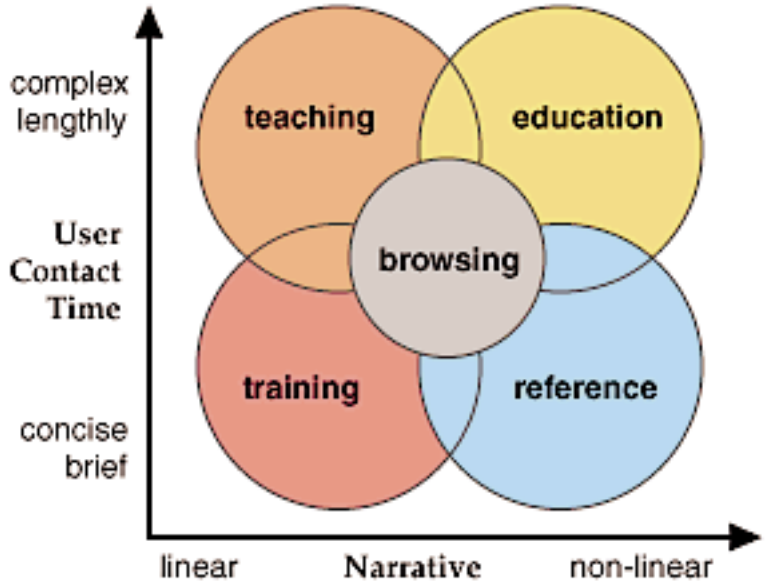
International users
Remember that you are designing for the World Wide Web. Your readers could be the people down the street, or people in Australia or Poland. To reach the maximum number of users in other countries you may need to provide translations, at least of your key menu pages. Avoid idiosyncratic local jargon or obscure technical acronyms in your introductory or explanatory pages. Don't assume that every reader follows your local date and time conventions. For example, don't abbreviate dates on your Web pages. To an American, "3/4/97" reads as "March 4, 1997," but users in most other countries would read the abbreviated date as "April 3, 1997."

References

December, J., and N. Randall. 1995. *The World Wide Web unleashed* . Indianapolis: Sams Publishing.

C/AIM

All presentations of information are governed by a few parameters determined by your objectives, the practical logistics of the medium you chose, and by the nature of your audience. The graphic below plots four major themes for intranet information delivery against two fundamental variables: how linear the structure of your presentation will be, and how long the typical user contact time will be:



Browsers
In the larger World Wide Web browsers ("Web surfers") are the unmotivated readers who may blow through your home page without an urgent mission or purpose in mind. Techniques for drawing these potential customers into a sales or entertainment site are beyond the scope of this manual, but you may find some guidance from these sources. The following categories of Web use are more typical of corporate and educational "intranet" sites where the users arrive with a more defined purpose.

Training
Web-based training applications tend to be very linear in design, and present few opportunities to digress from the central flow of the presentation. Don't confuse users or confound your own expectations by offering many links away from the central message. Restricting the links to "Next" and "Previous" paging functions guarantees that everyone sees the same presentation, and allows you to make more accurate predictions of user contact time. Most training presentations assume a contact time of less

than one hour, or are broken up into sessions of an hour or less. Inform your users about how long the session will last, and warn them not to digress away from the required material if they are to get credit for the training. Training applications typically require a user log-in, and often present forms-based quiz questions in true/false or multiple-choice formats. User log information and scores are typically stored in a database linked to the Web site.

Teaching
Good teaching applications are also built around a strong central narrative, but typically offer more opportunities for students to pursue interesting digressions from the main themes of the Web site. The information presented is usually more sophisticated and in-depth than in training applications. Links are the most powerful aspect of the Web, but they can also be a distraction that may prevent your students getting through the basic presentation. If you want to provide students with links to other Web-based resources beyond your local site you might consider grouping the links on a page separate away from the main body of the material. Often users will want to print the material from the Web and read it later from paper. Make this easy for them by providing a "printing" version that consolidates many separate pages into one long page.

Education
The audiences for heuristic, self-directed learning will chafe at design strategies that are too restrictive and linear. Often the typical user is already highly educated. Flexible, interactive, non-linear design structures are ideal for these users, because it is so difficult to predict exactly what topics will most interest an experienced professional or graduate student. The design must allow fast access to a wide range of topics, and is typically very dense with links to related material within the local Web site and beyond on the World Wide Web. Text-based lists of links work well here for tables of contents and indexes because they load fast and are dense with information, but this audience is also easily bored and needs the frequent stimulation of well-designed graphics and illustrations to stay involved with the material. Contact times are unpredictable, but will often be shorter than for training or education sites because the users are usually under time pressure. Easy printing options are also a must for this audience.

Reference
The best-designed reference Web sites allow users to quickly pop into the site, find what they want, and then easily print or download what they find. Typically there is no "story" to tell, so the usage patterns are totally non-linear. Content and menu structure must be carefully organized to support fast search and

retrieval, easy downloading of files, and convenient printing options. Keep the graphics minimal to speed download times, and you may want to investigate search software instead of relying exclusively on index-like lists of links. Contact time is typically brief, the shorter the better.

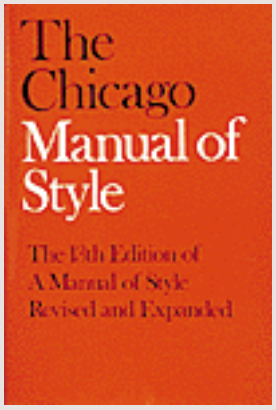
References

Mok, C. 1996. *Designing business: multiple media, multiple disciplines.* San Jose: Adobe Press.

Netscape Authoring Resources (get authoring resources URL)

Siegel, D. 1996. *Creating killer web sites.* Indianapolis: Hayden Books. www.killersites.com

Studio Archetype



Users of Web documents don't just look at information, they interact with it in novel ways that have no precedents in paper document design. The graphic user interface (GUI) of a computer system includes the interaction metaphors, images and concepts used to convey function and meaning on the computer screen, the detailed visual characteristics of every component of the graphic interface, and functional sequence of interactions over time that produce the characteristic "look and feel" of Web pages and hypertext linked relationships. Graphic design and visual "signature" graphics are not just used to "jazz up" Web pages--graphics are an integral part of the user's experience with your site. In interactive documents it is impossible to fully separate graphic design from issues of interface design.

Web pages versus conventional document design

Most of our current concepts about structuring information stem from the organization of printed books and periodicals, and the library indexing and catalog systems that developed around printed information. The "interface standards" of books in the English-speaking world are well established and widely agreed-upon, and detailed instructions for creating books may be found in guides like *The Chicago Manual of Style* . Every feature of a book, from the table of contents to the index and footnotes has evolved over the centuries, and readers of early books faced some of the same organizational problems facing the users of hypermedia documents today. Gutenberg's bible of 1456 is often cited as the first modern book, yet even after the explosive growth of publishing that followed Gutenberg it took more than 100 years for page numbering, indexes, tables of contents, and even title pages to become routine features of books. Web documents will undergo a similar evolution and standardization of the way information is organized and made available in electronic form.

Design precedents in print

Although networked interactive hypermedia documents do pose novel challenges to information designers, most of the guidance you need to design, create, assemble, edit, and organize multiple forms of media is not radically different from current practice in print media. Most Web documents can be made to conform to *The Chicago Manual of Style* conventions for editorial style and text organization. Most of what an organization needs to know about creating clear, comprehensive, and consistent internal publishing standards is already available in guides like the *Xerox Publishing Standards: A Manual of Style and Design* . Don't get so lost in the novelty of Web pages that basic standards of

editorial and graphic design get tossed aside.

Make your Web pages free-standing

World Wide Web pages are different from books and other documents in one crucial respect: hypertext links allow users to access a single Web page with no preamble. Thus Web pages need to be more independent than pages in a conventional book. This usually means that the headers and footers of Web pages are more informative and elaborate than printed pages. It would be absurd to repeat the copyright, author, and date of a book at the bottom of every page, but individual Web pages often need such information because a single Web page may be the only part of your site some users ever see. This problem of making documents free-standing is not unique to Web pages. Professional journals, magazines, and most newspapers repeat the date, volume, and issue numbers at the top or bottom of each printed page because they know that their readers often rip out newspaper articles or photocopy pages from journals and need that citation information to trace the original source of the article.

Given these potential difficulties in creating Web sites that are both easy to use and full of complex content, the best design strategy is to consistently apply a few basic document design principles in every Web page you create. The basic elements of a document aren't complicated, and have almost nothing to do with Internet technology. It's just like high school journalism class: who, what, when, and where.

Who

Who is speaking? This question is so basic, and the information is so often taken for granted that Web authors often overlook the most fundamental piece of information a reader needs to assess the provenance of a document: who is saying this to me? Whether the page is from an individual author or an institution, always tell your reader who created the Web page. The flood of Web sites propagating incorrect or actively misleading material on the TWA Flight 800 crash offer a vivid example of how "information" of no known origin or authenticity can quickly come to dominate legitimate inquiry and discussion.

What

All documents need clear titles to capture the reader's attention, but for several reasons peculiar to the Web this basic editorial element is especially crucial. The document title is often the first thing browsers of World Wide Web documents see as the page comes up. In pages with lots of graphics the title may be the only thing the users sees for several seconds as the graphics download onto the page. Additionally, the page title will become the text of a browser "bookmark" if the user chooses to add your page to their list of URLs. A misleading or ambiguous title, or a title that

contains more technical gibberish than English, will not help the user remember why they bookmarked your page.

When

Timeliness is an important element in evaluating the worth of a document. We take information about the age of most paper documents for granted: newspapers, magazines, and virtually all office correspondence is dated. So date every Web page, and change the date whenever the document is updated. This is especially important in long or complex online documents that are updated regularly, but that may not look different enough to signal a change in content to occasional readers. Corporate information, personnel manuals, product information, and other technical documents delivered as Web pages should always have revision dates.

Where

The Web is an odd "place" that has huge informational dimensions but few explicit cues to the physical location where a document originates. Click on a Web link, and you could be connected to a Web server in Sidney, Australia, Chicago, USA, or almost anywhere else with Internet connections. Unless you are well versed in parsing URLs it can be difficult to tell where a page originates. This is the World Wide Web after all, and the question of where a document came from is sometimes inseparable from who the document came from. Always tell the reader where you are from, with (if it is relevant) your corporate or institutional affiliations.

Incorporating the "home" URL on at least the main pages in your site is an easy means of maintaining the connection to where a page originated. Once the reader has saved the page as a text file or printed the page onto paper this connection may be lost. Although recent versions of the major Web browsers now allow you to automatically include the URL in anything you print, many people never take advantage of these optional features. Too many of us now have mountains of printed Web pages laying around and no easy way of re-finding the Web locations where those documents originated.

Consistently state the title, the author, the author's institutional affiliations, the revision date, and provide at least one link to a local home page in every WEB page in your system. Put the "home page" URL on a few major pages in your site. Include these basic elements and you will have gone 90% of the way toward providing your readers with an understandable Web user interface.

References

Lemay, L. 1996. *Teach yourself Web publishing in a week, 2nd ed*. Indianapolis: Sams Publishing.

December, J., and N. Randall. 1995. *The World Wide Web unleashed* . Indianapolis: Sams Publishing.

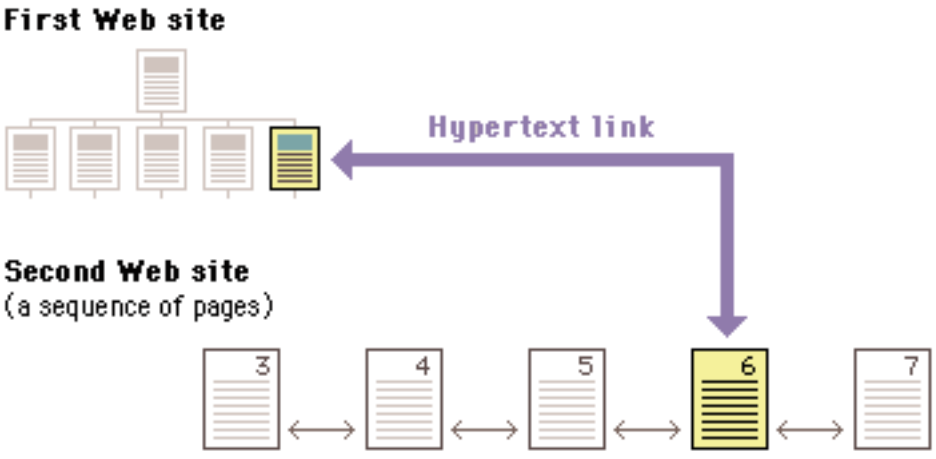
User-centered design

Graphic user interfaces were designed to give people direct control over their personal computers. Users now expect a level of design sophistication from all graphic interfaces, including Web pages. The goal is to provide for the needs of all of your potential users, adapting Web technology to their expectations, and never requiring the reader to simply conform to an interface that puts unnecessary obstacles in their paths.

This is where your research on the needs and demographics of your target audience is crucial. It's impossible to design for an unknown person whose needs you don't understand. Create sample scenarios with different types of users seeking information from your site. Would an experienced user seeking a specific piece of information be helped or hindered by your home page design? Would a novice be intimidated by a complex text-based menu? Testing your designs and getting feedback from users is the best way to see whether your design ideas are giving users what they want from your site.

Build clear navigation aids

At the current state of web technology most user interactions with Web pages involve navigating hypertext links between documents. The main interface problem in Web sites is the lack of a sense of where you are within the local organization of information. Clear, consistent icons, graphic identity schemes, and graphic or text-based overview and summary screen can give the user confidence that they can find what they are looking for without wasting time.



Users should always be able to easily return to your home page, and to other major navigation points in your local site. These basic links, that should be present on every page of your site, are

often graphic buttons that both provide basic navigation links, and help create the graphic identity that signals the user that they are still within your site domain. For example, in the Netscape corporate site this bar of buttons appears at the foot of every page:

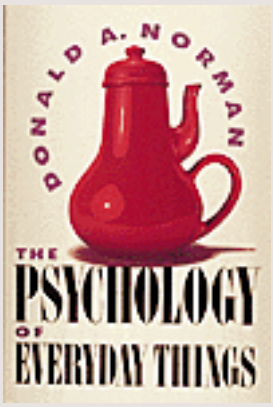
Graphic has been reduced from the original size. www.netscape.com

The button bar is useful (lots of choices in a small space), predictable (it is always there, at the bottom of every page), and provides a consistent graphic identity to every page in the Netscape site.

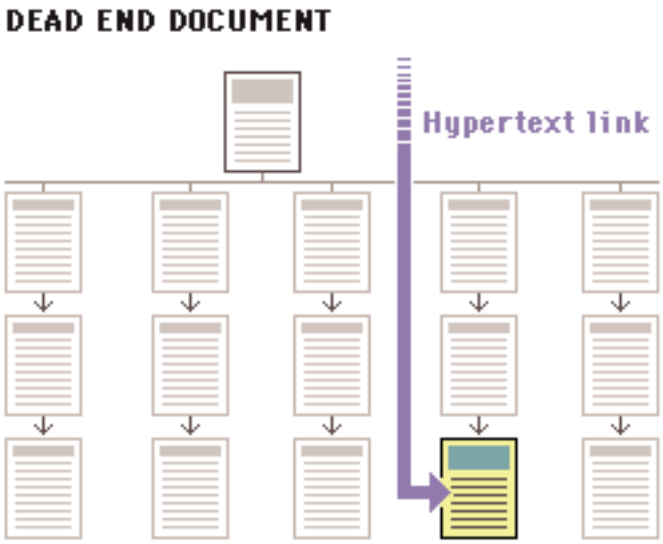
No dead-end pages

Every Web page should contain at least one link. "Dead-end" pages pages with no links to any other local page in the site are not only a frustration to users, they are often a lost opportunity to bring browsers into other pages in your site.

Web pages often appear with no preamble: readers often make or follow links directly to subsection pages buried deep in the hierarchy of Web sites. Thus they may never see your Home Page or other introductory information in your site. If your subsection pages do not contain links back up the hierarchy, to the home page or to local menus pages, the reader is essentially locked out of access to the rest of your Web site:



C/AIM



References

Apple Computer, Inc. 1992. *Macintosh human interface guidelines.* Reading, MA: Addison-Wesley.

Mullet, K., and D. Sano. 1995. *Designing visual interfaces.* Englewood Cliffs, NJ: SunSoft Press-Prentice Hall.

Netscape Home Page

Norman, D. A. 1988. *The psychology of everday things.* New York: Basic Books.

Give users direct access

The goal here is to provide the user with the information they want in the fewest possible steps, and in the shortest time. This means you must design an efficient hierarchy of information, to minimize the number of steps through menu pages. Interface studies have shown that users prefer menus that present a minimum of five to seven links, and that users prefer a few very dense screens of choices over many layers of simplified menus.

In the table below note that you do not need many levels of menus to incorporate large numbers of choices:

Number of nested menus	Number of menu items listed			
	5	7	8	10
1	5	7	8	10
2	25	49	64	100
3	125	343	512	1000

Bandwidth and interaction

Users will not tolerate long delays. Human-factors research has shown that for most computing tasks the threshold of frustration is around 10 seconds. Web page designs that are not well "tuned" to the network access speed of your typical users will only frustrate them. If your users are primarily general public browsers "surfing" the Web via 28.8 kbps phone line connections it is foolish to put huge bitmap graphics on your pages the average user will not be patient enough to wait endlessly while your graphics download over the phone line. However, if you are building a university or corporate Intranet site where most users will be accessing your Web server at Ethernet speeds or better you can be much more ambitious in your use of graphics and multimedia.

Simplicity and consistency

Users are not impressed with complexity that seems gratuitous, especially users who may be depending on your site for timely and accurate work-related information. Your interface metaphors should be simple, familiar and logical to the audience if you want a metaphor for information design, choose a book or a library, not a spacecraft or a television set. The best information designs are the ones most users never notice.

Studio Archetype's work for the Adobe Corporation site is an

excellent model of Web site design. The pages use graphics extensively as navigation aids, consistently applied across every one of the pages in the site. Once you know where the standard links are on the page header graphics, the interface becomes almost invisible and navigation is easy.

Graphic has been reduced from the original size. www.adobe.com

For maximum functionality and legibility your page and site design should be built on a consistent pattern of modular units, all sharing the same basic layout grids, graphic themes, editorial conventions, and hierarchies of organization. The goal is to be consistent and predictable, so that your users will feel comfortable exploring your site, and confident that they know how to find what they are looking for. The graphic identity of a series of pages in your Web site provides visual cues to the continuity of information. The header menu graphics present on every page of the Adobe site create a consistent user interface, and a consistent corporate identity:

Graphic has been reduced from the original size. www.adobe.com

Even if your page uses no inlined graphics, a consistent approach to the layout of titles, subtitles, page footers, and navigation links to your home page or related pages will also reinforce the reader's

sense of context within your site organization.

To preserve the effect of a "seamless" system of pages you may want to consider bringing important information into your local site and adapt it to your page layout scheme rather than using links to send the reader away from your site (if there are no copyright restrictions on copying the information into your local site).

Designstability

If you want to convince your users that what you have to offer is accurate and reliable you will have to design your Web site just as carefully as you would any other type of corporate communication, with the same high editorial and design standards. A site that looks sloppily-built, with poorly visual design and low editorial standards will not inspire confidence in your users.

Functional stability in your Web design means keeping the interactive elements of your site working reliably. Functional stability has two components getting things right the first time as your design your site, and then keeping things functioning smoothly over time. Good Web sites are inherently interactive, with lots of links to local pages within the site, and links to other sites on the Web. As you create your design you will need to constantly check to be sure that all of your links work properly. things change quickly on the Web, both in your site and everyone else's. You will need to periodically check to be sure that you links are still working properly, and that the content they supply is still relevant to your needs.

Feedback and dialog

Your Web design should offer constant visual and functional confirmation of the user's whereabouts and options, via graphic design, navigation buttons, or uniformly-placed hypertext links.

Feedback also means being prepared to respond to your user's inquiries and comments. Well-designed Web sites should always provide direct links to the site's editor or the "webmaster" responsible for running the site. Planning for this kind of on-going relationship with the users of your site is vital to the long-term success of the enterprise.

C/AIM

Design for the disabled

Not every user of your site will be able to take advantage of the graphics you offer on your pages, and a number of users may be visually impaired. One of the beauties of the Web and HTML is the ability to build in "alternate" messages ("ALT" tags in HTML) so that users without graphics capabilities can still understand the function of graphics on your pages. Using specially designed software, blind users can hear (via synthesized speech) the alternate messages you supply along with your graphics, and so will not completely miss the content of your pictures and graphic navigation buttons. If you will be using graphic menu systems for navigation, these text-based alternate menus will be an especially important aid to users without the ability to see your graphics.

References

Adobe Corporation. www.adobe.com

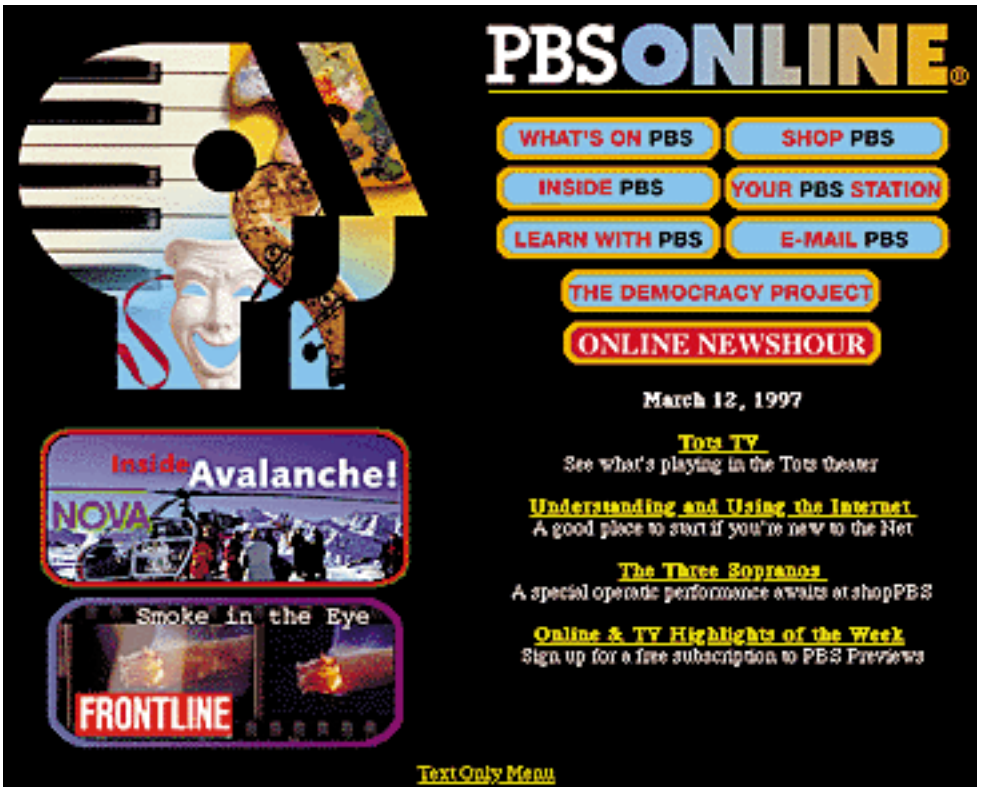
Apple Computer, Inc. 1992. *Macintosh human interface guidelines.* Reading, MA: Addison-Wesley.

Microsoft Corporation. 1995. The windows interface guidelines for software design. Redmond, WA: Microsoft Press.

Shneiderman, B. 1992. *Designing the user interface: Effective strategies for effective human-computer interaction. 2nd ed.*, Reading, Mass.: Addison-Wesley.

Studio Archetype

Providing a rich set of graphic navigation and interactivity links within your Web pages will pull the user's attention down the page, weaning them away from the general-purpose browser links, and drawing them further into your content. By providing your own consistent and predictable set of navigation buttons you also help give the user an sense of your site's organization, and makes the logic and order of your site visually explicit. Here the rich graphics and many links offered by the PBS home page immediately draw the reader into the site:

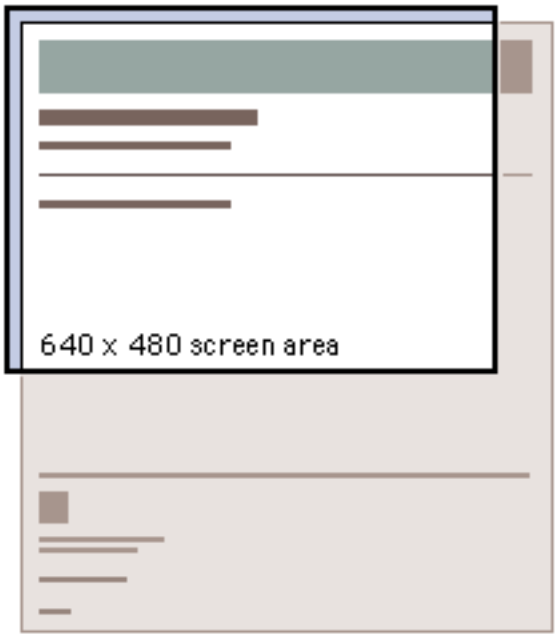


Graphic has been reduced from the original size. www.pbs.org

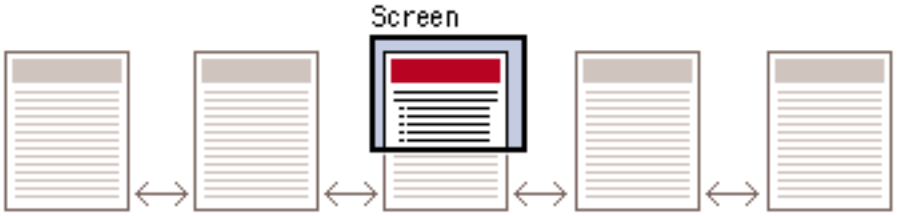
Provide context or lose the reader

Readers need a sense of context, of their place within an organization of information. In paper documents this sense of "where you are" is a mixture of graphic and editorial organizational cues supplied by the graphic design of the book, the organization of the text, and the physical sensation of the book as an object. Electronic documents provide none of the physical cues we take for granted in assessing information. When we see a Web hypertext link on the page we have few cues to where we will be led, how much information is at the other end of the link, and exactly how the linked information relates to the current page. Even the view of individual Web pages is restricted

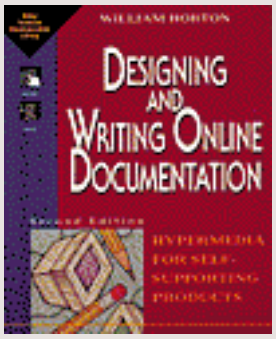
for most users. Most Web pages don't fit completely on an standard office 14-inch or 15-inch display monitor, and thus there is always part of the page that the user cannot see.



Web pages need to give the user explicit cues to the context and organization of information, because only a small portion of your site (less than a page) is visible at one time:



As the Web page designer it is up to you to provide these functional and context cues to the reader.



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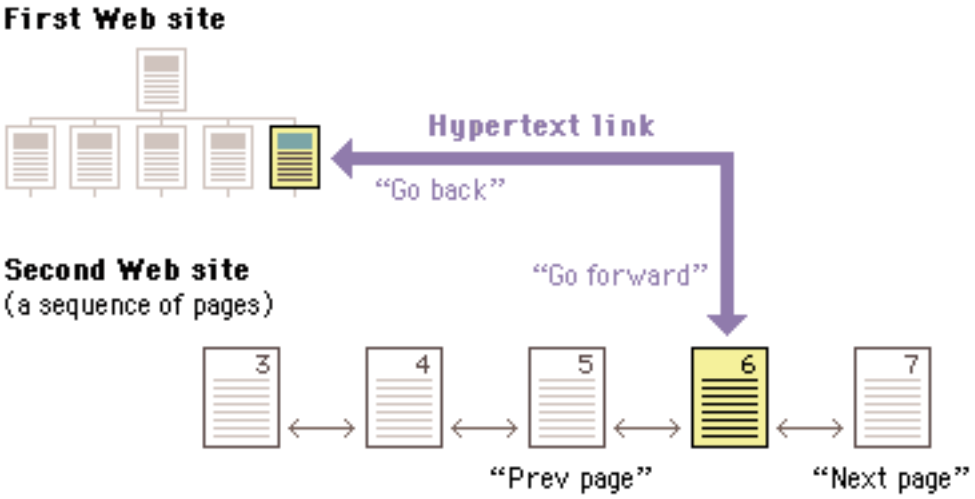
Horton, W. K. 1994. *Designing and writing online documentation, 2nd edition.* New York: Wiley.

PBS Online. Public Broadcasting Corporation Web site.

C/AIM

"Going back" and going to the previous page

All hypertext systems share a common problem that has no direct precedent in print media: going "back" through a series of links you have previously visited is not the same as paging "back" through the preceding pages of an ordered sequence of pages. When users click on a hypertext link in a Web document they often are transported from one Web site to another, perhaps even from one country to another. Once made the hypertext link is bi-directional; you can "go back" to the Web site you just left by clicking on the "Back" button of the viewer. Having hit the "Back" button, the "Forward" button lets you move to the new Web site again.



Why button bars are useful

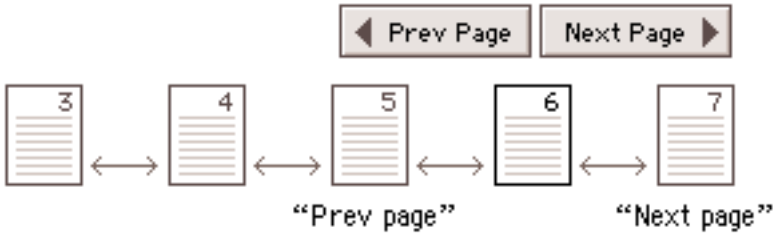
For the information designer hypertext links are a mixed blessing. The radical shifts in context that links create can easily confuse Web users, who need organized cues and interface elements if they are to follow and understand hypertext links from one Web page to another. This is particularly true when you want users to be able to follow (or at least recognize) an ordered sequence of documents. Notice in the diagram above that although the user has entered the second Web site at page 6, the site is an ordered sequence of pages.

By augmenting the standard Web viewer "Back" and "Forward" buttons with "Next Page" and "Previous Page" buttons built into the page itself the user then has interface tools to navigate through the information in the second site in the sequence the author intended:

Fixed versus relative links

Unlike the "Back" and "Forward" buttons in Web viewers like

Netscape and Mosaic, whose only functions are relative to the pages you have seen most recently, "Next Page" and "Previous Page" buttons in a document are fixed links you provide to other associated documents. By providing the user with paging buttons and links to local home pages and tables of contents you give your users the tools to understand how you have organized your Web site information, even if they have not entered your web of pages through a home page or table of contents page. The buttons don't prevent you from reading the information in whatever order you choose, but they do allow your reader to follow the sequence of pages you have laid out:



Button bars are also the most logical place to put links back to your home page, or to other menu pages related to the current page. A button bar can be built with text (like ours at C/AIM, below), or a series of individual button graphics at the top or bottom of the page:

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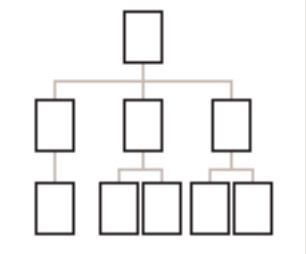


There are fundamental rhetorical and organizational reasons for subdividing any large body of information, whether it is delivered on the printed page or in a World Wide Web site. Underlying all organizational schemes are the limitations of the human brain in holding and remembering information. Cognitive psychologists have known for decades that most people can only hold about four to seven discrete chunks of information in short-term memory. The goal of most organizational schemes is to keep the number of local variables the reader must keep in short-term memory to a minimum, using combination of graphic design and layout conventions along with editorial division of information into discrete units. The way people seek out and use information also suggests that smaller, discrete units of information are more functional and easier to navigate through than long, undifferentiated units.

Most Web sites contain reference information that people seek in small units. Users rarely read long contiguous passages of text from computer screens, and most people who are seeking a specific piece of information will be annoyed to have to scan long blocks of text to find what they are after. Small chunks of related information are also easier to organize into modular units of information that all share a consistent organization scheme that can form the basis for hypertext links within your Web site. "Small" can only be determined in the context of your presentation and what you expect of the audience. In this style manual our expectation is that most people will print these pages and read them from paper "off-line," so we have tried to divide the manual into Web pages that will that will print as logical units.

Steps in organizing information

Day-to-day professional and social life rarely demands that we create detailed hierarchies of what we know and how those bits relate to each other, but without a solid and logical organizational backbone your Web site will not functional well even if your basic content is accurate and well-written. The four basic steps in organizing your information are to divide it into logical units, establish a hierarchy of importance and generality, use the hierarchy to structure relationships among chunks, then analyze the functional and aesthetic success of your system.

Chunking information

Most information on the World Wide Web consists of short reference documents are read non-sequentially. This is particularly true of educational, corporate, government, and

organizational web sites used to distribute information that might have been printed on paper a few years ago. Writers of technical documents discovered long before the Web was invented that users appreciate short "chunks" of information that can be scanned and located quickly. Short, uniformly-organized chunks of information particularly lend them to Web presentation, because:

- Few Web users spend time reading long passages of text on-screen. Most users will save long documents to disk, or print them, rather than read extensive material online.
- Discrete chunks of information lend themselves to Web links. The user of a link usually expects to find a specific unit of related information, not a whole book's worth of information to filter through. But don't subdivide your information too much, or you will frustrate your readers. One to three (printed) pages of information seems about right for a discrete chunk of information on the Web. A link that produces only a small paragraph of information would be silly in most situations.
- A uniform format for organizing and presenting your information allows users to apply their past experience with your site to future searches and explorations, and allows users to predict how an unfamiliar section of your Web site will be organized.
- Concise chunks of information are better suited to the computer screen, which provides a only limited view of long documents. Very long Web pages tend to be disorienting, because they require the user to scroll long distances, and to remember the organization of things that have scrolled off-screen.

The concept of a chunk of information must be flexible, and consistent with common sense, logical organization, and the convenience of the Web site user. Let the nature of the content suggest the best ways to subdivide and organize your information. There will be times when it makes sense to provide long documents in single Web pages, as integrated units of information. Although chunks of information in online documents should usually be kept short, it makes little sense to arbitrarily divide up a long document. This is particularly true when you want users to be able to print or save the document in one step.

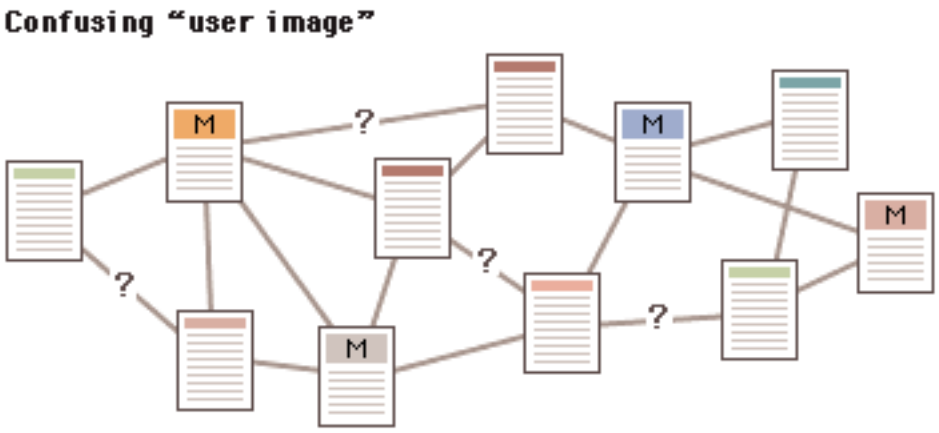
Hierarchy

Any organization needs a hierarchy of importance, if only to determine basic navigation structures for the user. Most "chunks" of information can and should ranked in importance,

and organized by the degree of interrelationship among units. Once you have determined a logical set of priorities, you can build a hierarchy from the most important or most general concepts, down to the most specific or optional topics. Hierarchical organizations are virtually a necessity on the Web, because most home page-and-link schemes depend on hierarchies, moving from the most general overview of your site (your home page), down through submenus and content pages that become increasingly more specific.

Relationships

When confronted with a new and complex information system users begin to build mental models, and then use these models to assess relationships among topics, and to make guesses about where to find things they haven't seen before. The success of your Web site as an organization of information will largely be determined by how well your actual organization system matches your user's expectations. A logical site organization allows users to make successful predictions about where to find things. Consistent methods of grouping, ordering, labeling, and graphically arranging information allows user to extend their knowledge from pages they have visited to pages they are unfamiliar with. If you mislead users with a structure that is not logical (or have no comprehensible structure at all), users will be constantly frustrated by the difficulties of find their way around. You don't want your user's mental model of your site to look like this:

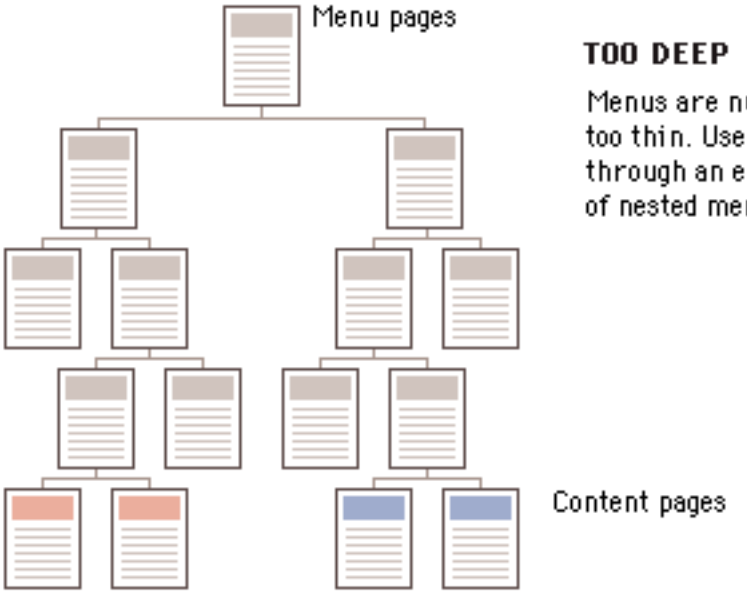


Function

After you have created your site, you should analyze its aesthetics, and the practicality and efficiency of your organizational scheme. No matter what organizational structure you choose for your Web site, proper World Web site design is largely a matter of balancing the structure and relationship of menu or "home" pages and individual content pages or other linked graphics and documents. The goal is to build a hierarchy of menus and pages that feels natural to the user, and doesn't interfere with their use of the Web site or mislead them.

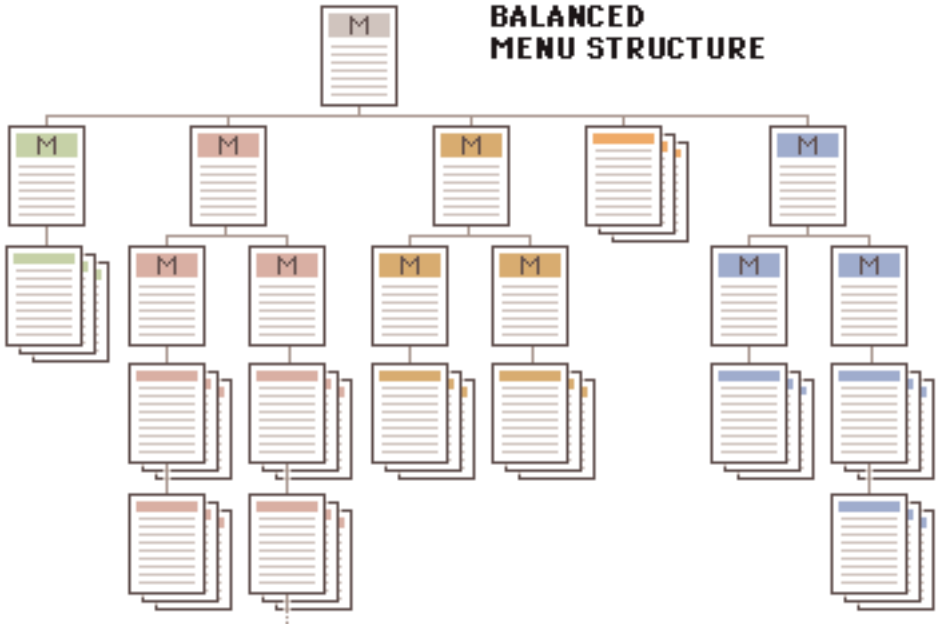
Web sites tend to grow almost organically, and often overwhelm what was originally a reasonable menu scheme. WWW sites with too shallow a link hierarchy depend on massive menu pages that over time devolve into confusing "laundry lists" of unrelated information, listed in no particular order:

Menu schemes can also be too deep, burying information beneath too many layers of menus:



Gopher sites are the classic example of the disadvantages of nested menus, where you sometimes have to open many folders before you hit any content documents. Menus lose their value if they don't carry at least four or five links; text or list-based menu pages can easily carry a dozen links without overwhelming the user or forcing users to scroll through long lists. Having to navigate through many layers of nested menus before you reach any real content is infuriating and unnecessary.

If your Web site is actively growing, the proper balance of menus and pages is a moving target. User feedback (and analyzing your own use of your Web site) can help you decide if your menu scheme has outlived it's usefulness or has poorly designed areas. Complex document structures require deep menu hierarchies, but users should never be forced into page after page of menus if direct access is possible. The goal is to produce a well-balanced hierarchical tree that facilitates quick access to information and helps users understand how you have organized things.



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C/AIM

There are fundamental rhetorical and organizational reasons for subdividing any If you are interested in the World Wide Web you can hardly escape references to hypertext and hypermedia. These days the computer press is full of very fuzzy thinking about how Web-based information can somehow "link everything to everything." The implication is that with the Web you can probably dispense with one of the most challenging aspects of presenting information how to put it into logical order and create an interesting and understandable resource for the user. Nothing could be further from the truth. If you have only hazy idea how one section of your site relates to other areas, if you have no comprehensive narrative or clear sense of organization, your readers will know it soon enough, and most of them will leave in pursuit of better organized material.

Sequence

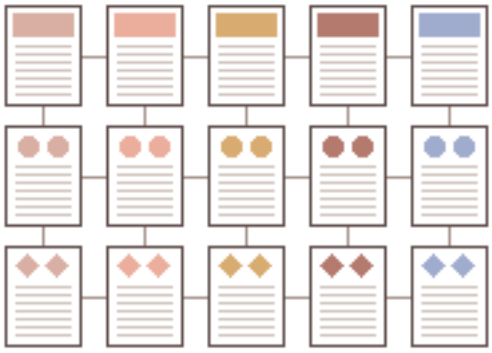
The simplest way to organize information is in a sequence, where you present a linear narrative. Information that naturally flows as a narrative, time line, or in logical order is idea for sequential treatment. Sequential ordering may be chronological, a logical series of topics progressing from the general to the specific, or even alphabetically sequenced, as in indexes, encyclopedias, and glossaries. However, simple sequential organization usually only works for smaller sites (or structured lists like indexes), as long narrative sequences often become more complex, and thus require more structure to remain understandable.

More complex Web sites may still be organized as a sequence, but each page in the main sequence may have one or more pages of digressions, parenthetic information, or links to information in other Web sites.

Grid

Many procedural manuals, lists of university courses, or medical case descriptions are best organized as a grid. Grids are a good way to correlate variables, such as a time line versus historical information in a number of standard categories such as "events," "technology," "culture," etc. To be successful, the individual units in a grid must share a *highly* uniform structure of topics and subtopics. The topics often have no particular hierarchy of importance. For example, "tuberculosis" is not more or less

important a diagnosis than "hilar adenopathy," but ideally both case descriptions would share a uniform structure of subtopics. Thus the user could follow the grid "down," reading about tuberculosis, or cut "across" the grid perhaps by comparing the "diagnostic imaging" sections of both hilar adenopathy and tuberculosis. Unfortunately, grids can be difficult to understand unless the user recognizes the interrelationships between categories of information, and so are probably best for experienced audiences who already have a basic understanding of the topic and its organization. Graphic overview maps are very useful in grid-like Web sites.

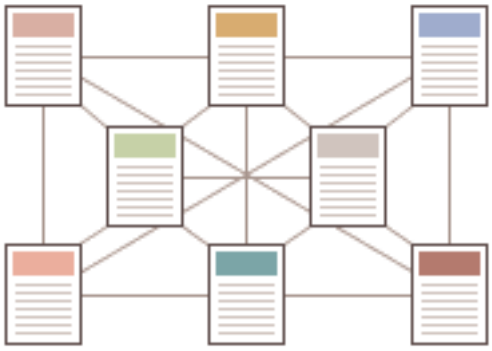


Hierarchy

Information hierarchies are one of the best ways to organize complex bodies of information. Hierarchical organization schemes are particularly well-suited to Web sites, because Web sites should always be organized as off-shoots of a single home page. Most users are familiar with hierarchical diagrams, and find the metaphor easy to understand as a navigational aid. A hierarchical organization also imposes a useful discipline on your own analytical approach to your content, as hierarchies only work well when you have thoroughly organized your material. Since hierarchical diagrams are so familiar to in corporate and institutional life, users find it easy to build mental models of the site:

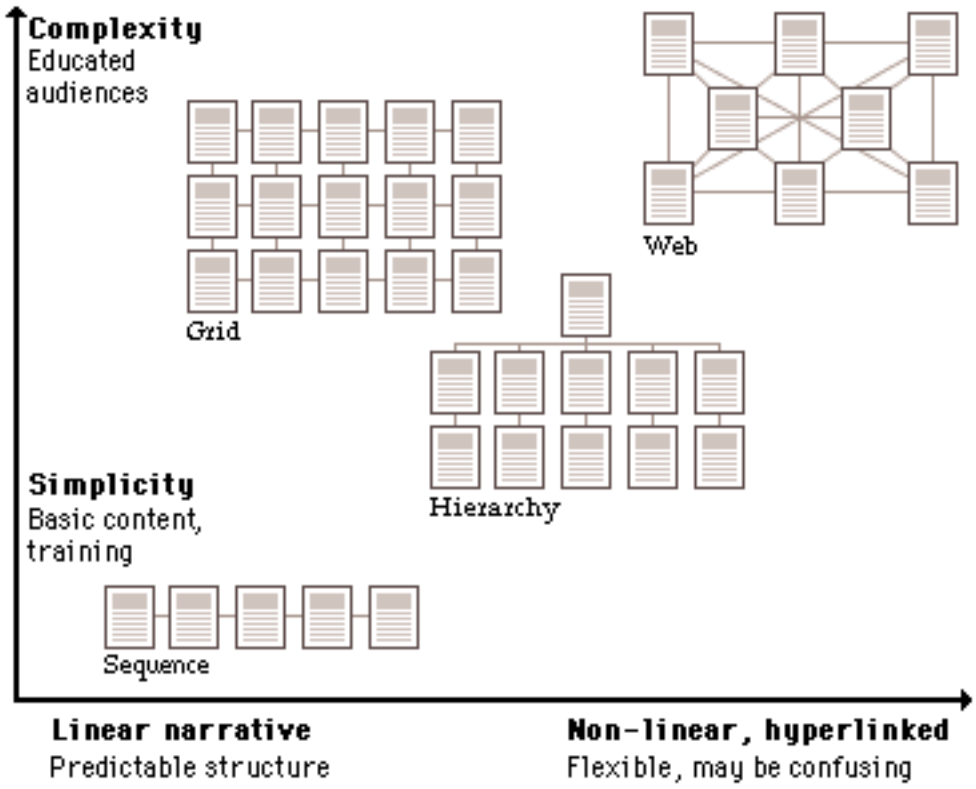
Web

Web-like organizational structures pose few restrictions on the pattern of information use. The goal is often to mimic associative thought and free flow of ideas, where users follow their interests in a heuristic, idiosyncratic pattern unique to each person who visits the site. This organizational pattern develops in Web sites with very dense with links both to other information within the site, and information on other World Wide Web sites. The goal is to fully exploit the Web's power of linkage and association, but web-like organization structures can just as easily propagate confusion and fuzzy thinking about the interrelationships of your information chunks. Ironically, organizational webs are often the most impractical structure for Web sites, because they are so hard for the user to understand and predict. Webs work best for small sites dominated by lists of links, aimed at highly educated or experienced users looking for further education or enrichment, not for a basic understanding of your topic.



Summary

Most complex Web sites share aspects of all four types of information structures. Except in sites that rigorously enforce a sequence of pages, your users are likely to use any Web site in a free-form "web-like" manner, just as most non-fiction or reference books are used. But the nonlinear usage patterns typical of Web surfers do not absolve you of the need to organize your thinking and present it within a clear, consistent structure that complements your design goals for the site. The chart below summarizes the four basic organization patterns against the "linearity" of your narrative, and the complexity of your content.



C/AIM

Web sites can vary enormously in their style, content, organization, and purpose, but all Web sites that emphasize designed to act as information resources share some basic characteristics.

Home pages
All Web sites are organized around a "home page," that acts as a point of entry into the complex of Web pages in your site. In hierarchical organizations, your home page sits at the top of the chart, and all pages in your Web site should be contain a direct link back to that home page. The World Wide Web URL for your home page is the Web "address" you will use to point users to your Web site, and the address of your home page could become every bit as important as your street address or department address in the years to come. The top of your home page will be the first thing Web users see when accessing your site (or your whole company, in the case of corporate Web sites), so the proper design of home pages is crucial to the success of your site. Design strategies for home pages vary, based on the function and needs of typical users of the site, the esthetic and design goals for the site, and on nature and complexity of the organization of the Web site as a whole.

Graphic or text menus
The most basic layout decision you will make about your home page concerns how heavily you will use graphics on the page. Most corporate, institutional, and education home pages display at least a small graphic banner across the top of the home page, and in commercial sites the trend is rapidly moving toward menus constructed from complex, full-page graphics the emulate the look and functions of CD-ROM multimedia title pages. While strong graphic can be effective at grabbing a browser's attention, large graphic menus impose long loading times for pages, especially for users linking to the Internet via modems or slower network connections. Even if the user is accessing your Web site at Ethernet speeds (10 Mbits/sec) graphic menus may still ten times slower than text-based lists of links.

Who is the audience for the home page?
This dichotomy between slow-loading but attractive graphics-based home pages and fast-loading but prosaic text-based home pages also reflects the need to address different audiences, with different expectations. The goals for most Web sites are the transmission of internal information (to students, employees, and existing clients) and communicating with potential clients and the general Web-browsing public. Kodak has opted for

graphic home page design, but the layout is carefully designed not to exceed the dimensions of the average office monitor. By keeping the graphic moderate in size the page loads reasonably quickly for a graphic menu.

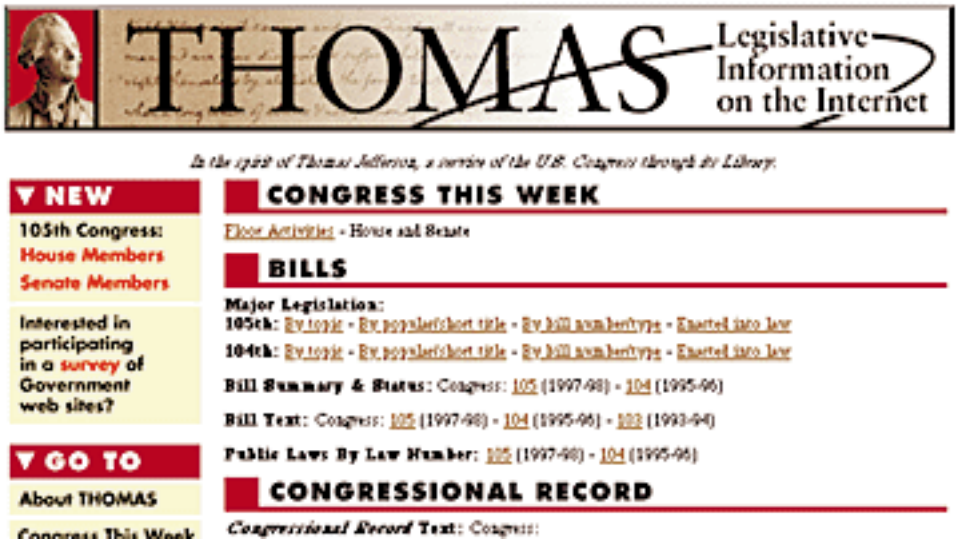
Graphic has been reduced from the original size. www.kodak.com

The relatively plain, mostly text-based home page for the W3C offers a very efficient ratio of links per kilobyte of page size, but at some cost in pure visual appeal. The page is fast-loading and well designed for its audience of Web specialists, but would not attract the average browser through presentation alone:

Graphic has been reduced from the original size. www.w3.org/pub/WWW/

Don't choose have it both ways

The best way to meet the needs of both casual browsers and highly targeted frequent users is to offer alternative views of you Web site. One approach is to make an visually attractive main home page aimed at the general audience of Web browsers, but also offer a more text-oriented alternate home page that emphasizes rapid access to information via detailed text menus. Another approach is to use a graphic banner up at the top of the home page, followed by a dense set of text-based links. The Library of Congress's Congressional information Web site "Thomas" reflects this dual approach, with a moderate graphic topping a dense but well-organized set of text links:



Graphic has been reduced from the original size. thomas.loc.gov/

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Eastman_Kodak

Thomas (U.S. Library of Congress Web site)

World_Wide_Web_Consortium (W3C)

Managing time
Many Web sites must be frequently updated so the information doesn't get stale. But the presence of the new information may not be obvious to readers of your Web site unless you make a systematic effort to let them know about it. If items listed the on the menus on your home page are updated you could just put a "NEW" graphic next to each updated item. You should also date every one of your Web pages, and update that as information changes so that users can be sure that they have the latest version of things. However, if your site is complex, with many levels of information spread over dozens (or hundreds) of pages you might be better off making a "What's New" page that is specifically designed to inform users that information in your site has been updated. You may also want to use a "What's New" page as a university or institutional newsletter, emphasizing timely information in your organization.

Menus, submenus, and home pages
Unless your site is very small you will probably need a number of submenu pages that the user enters from general category listing on your home page. In complex sites with dozens of topic areas it is not practical to load up the home page of a Web site with dozens of links the page gets too long to load in a timely manner, and the sheer complexity of long pages may be off-putting to many users.

Each major submenus in effect becomes a mini-home page for that section of your Web site. For specialized, detailed menus you may encourage frequent users to link directly to a submenu in your Web site. Thus the submenus could become alternate home pages oriented to specific groups of users. Just make sure to include a basic set of links to other sections of your site on each submenus, and most important of all, always include a link to a menu or home page on every Web page in your site.

"Other related sites" catalogues
The World Wide web is growing so rapidly that even the large commercial Web index services like Yahoo are only partial listings of the information that is accessible from the Web. Often the first sets of links Web users make when they begin to build their own Web sites are collections of favorite links to sites related to their professions, industries, or personal interests. In a corporate or institutional site a well-edited, well-maintained "other sites" page may be the most valuable and heavily-used resource in your Web site.

Bibliographies, indexes, appendices

The concept of "documents" in electronic environments like the Web pages is often flexible, and the economics and logistics of digital publishing make it possible to provide more information to your site users without the costs associated with paper documents. To make a report available to colleagues on paper you would have to print a copy for each person. Costs and practicality dictate that paper reports be very concise, and without much supporting material or appendices thus your audience is often left without access to the information upon which the writers based their conclusions for no reason other than the high cost of printing on paper. Aside from the main body of reports, you may wish to include lists of resources that would not normally be included in corporate reports because of space and cost considerations, but which could be made available in a Web site. Bibliographies, glossaries, appendices of information that might be too bulky to load into a task force report or committee recommendations document could be placed in a Web site instead, making the information available to other researchers without over-stuffing reports with material of interest to only a few readers.

Frequently asked questions FAQ pages

The web and other Internet-based media have evolved a unique institution, the FAQ, or "Frequently Asked Questions" page where the most commonly asked questions from users are listed along with answers. FAQ Web pages are ideal for Web sites designed to provide support and information to a working group within an institution, or to a professional or trade group that maintains a central office staff. Office staff and public relations personnel know that most questions new users ask have been asked and answered many times before. By making a well-designed FAQ page and referring users to it you could significantly improve the user's understanding of the information and services offered through your Web site or professional group. The FAQ page could also sharply reduce the time demands on your support staff who normally answer those routine, repetitive questions from users or clients.

References

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Lemay, L. 1996. *Teach yourself Web publishing in a week, 2nd ed.* Indianapolis: Sams Publishing.

We seek clarity, order, and trustworthiness in information sources, whether they are traditional paper documents or Web pages. The spatial organization of graphics and text on the Web page can engage the user with graphic impact, direct the user's attention, prioritize information, and make the user's interactions with your Web site more enjoyable and more efficient.

> **"Man is the great pattern-maker and pattern perceiver. No matter how primitive his situation, no matter how tormented, he cannot live in a world of chaos."**
> Edmund Carpenter

Design and visual logic

Graphic design creates visual logic, an optimal balance between visual sensation and graphic or text information. Without the visual impact of shape, color, and contrast pages are often graphically boring and will not motivate the viewer to investigate their contents. Dense text documents without the contrast and visual relief offered by graphics and careful page layout and typography are also more difficult to read, particularly on the relatively low-resolution screens of current personal computers. However, without the depth and complexity of text, highly graphic pages risk disappointing the user by offering a poor balance between visual sensation, text information, and interactive hypermedia links. In seeking this ideal balance, the primary graphic design constraints in Web pages are the vertical, list-oriented structure of HTML as seen in current Web browsers like Netscape and Internet Explorer, and the practical bandwidth limitations on user access rates that may currently range from 14.4 modems to Ethernet speeds or better.

Visual and functional continuity in your Web site organization, graphic design, and typography is essential to convince your audience that your Web site offers them timely, accurate, and useful information. A careful, systematic approach to page design can simplify navigation, reduced errors, and make it much easier for users to take full advantage of the information and features of your Web site.

Graphic Design and the Web

Hypertext Markup Language (HTML), the language of Web page design, is a hypertext system, emphasizing interactive linkages between graphic, text, or media documents. The ability to mix graphics or motion media with text in HTML is much more

limited than in other forms of electronic document authoring, or in paper-based publishing. The graphic design vocabulary within HTML is constrained by the vertical list structure of HTML and the uncertainties of designing with device-independent physical and logical typographic controls. However, the ability to imbed hypertext links text and graphics that can take full advantage of the Internet offers unprecedented functional power and flexibility in designing interlinked, interactive information systems.

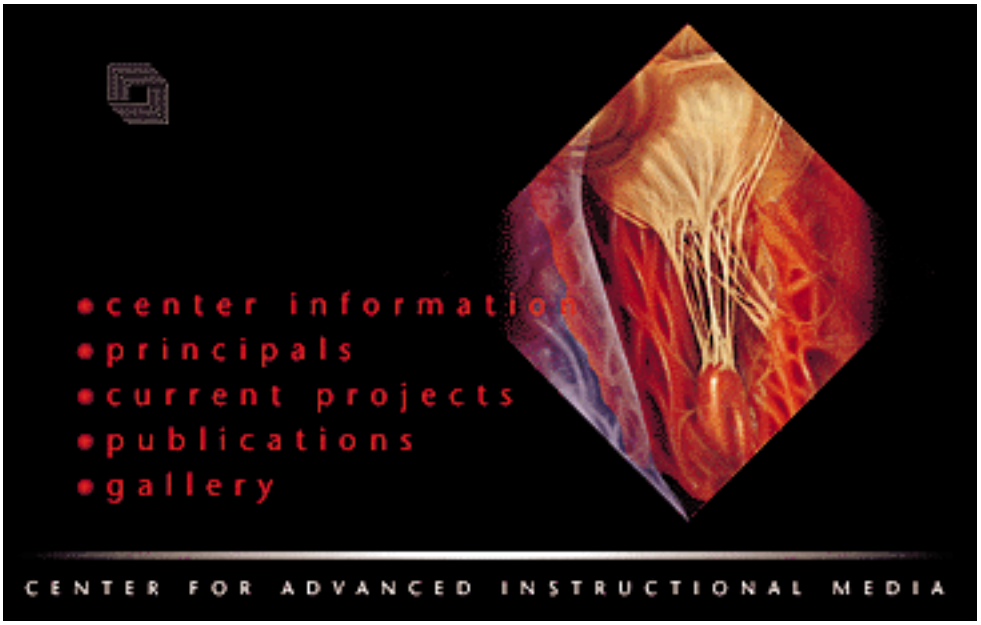
Efficient Use of the World Wide Web

Although the prospect of networked multimedia in Web pages is exciting, the highly graphic interface design now seen in consumer-oriented CD-ROM multimedia titles is a particularly poor model for current Web page designs. Such highly graphic designs require far more communications bandwidth than even Ethernet typically delivers to current personal computers. Purely graphic menu designs for Web pages that depend on one large imagemap graphic are fine for corporate or educational Intranet use, but are likely to try the patience of users accessing the web via modem.

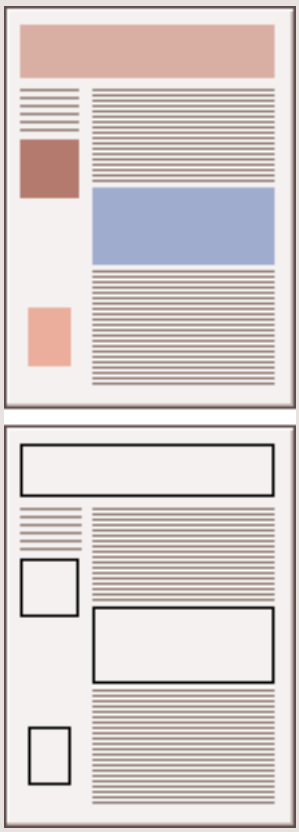
Sites like FedEx's home page design (below) emulate the graphic menus seen in multimedia CD-ROMs. Highly graphic menu screens produce visual impact (eventually), but they also impose long waits on users who do not have access to high-bandwidth Internet connections like ISDN or Ethernet. FedEx is betting that most users of their site are repeat viewers who have this large graphic in stored in their browser's cache, available for fast loading on return visits:

Graphic has been reduced from the original size. www.fedex.com

What excites most people about the Web is the promise of graphic communication, and graphic "splash screens" or home pages can be very successful as long as you fully understand the convenience trade-offs and performance compromises and do not alienate your target audience. Our C/AIM home page design is now a graphic menu that uses JavaScript to randomly choose one of 12 alternate designs to display each time the page is loaded. We chose graphic impact over the diversity of text links because our basic home page menu was short, our focus is multimedia communication, and our target audience is mostly fellow academics and physicians with high-bandwidth access to the Web.



Graphic has been reduced from the original size. www.med.yale.edu/caim/



Graphics and system responsiveness

As Web systems evolve from informal novelties into widespread organizational, educational, and corporate use the expectations for system performance are increasing. For an large organization using a Web intranet system as a management information tool the aggregate effect of the long delays caused by inappropriate use of over-large graphics or other inefficiencies in key menu areas may cripple the cost-effectiveness of the system. This is especially true when many users are accessing your Web site via modems, such as home-office telecommuters, distance-learning students, your sales force, or your field personnel. Most studies on user response to computing system delays suggest that waiting times longer than about 10 seconds are intolerable in routine, repetitive computing tasks. For the past few years the (very slow) Web has gotten a free pass due to its novelty, but it seems unlikely that users will be any more tolerant of Web systems than they are of any other networked service or computing task.

With or without graphics?

If you are currently using a large graphic menu on your site's home page, you should take a close look at the log of "hits" produced by your Web server software. (Your Web server administrator should be able to produce this log for you if you've never seen one.) The server log shows how many times your home page has been requested, or "hit," by readers looking at your page. Each GIF or JPEG graphic image used on your home page should also show a corresponding hit, as the graphics files are requested and downloaded to the reader. If the number of hits on your home page HTML file is significantly larger than the number of hits on the graphic files used on your home page then you know that many users are accessing your page with the graphics turned off in their Web browsers. If your readers are turning off the graphics because your site takes so long to download, then all of the information you have placed into your Web page graphics never reaches your readers.

References

FedEx, Inc.

Center for Advanced Instructional Media, Yale University

C/AIM

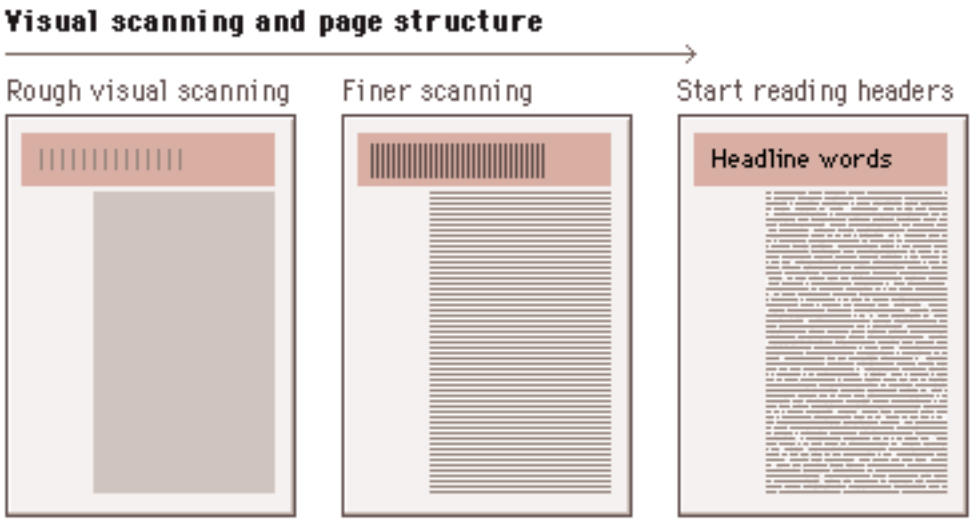
Understand the medium

Readers experience Web pages in two ways: as a direct medium where pages are read online, and as a delivery medium to access information that is later downloaded into text files or printed onto paper. Your expectations about how readers will use typically use your site should govern your design decisions. Documents to be read online must be concise, with the amount of graphics carefully "tuned" to the bandwidth available to the mainstream of your audience. But don't patronize your readers or insult their intelligence. The common advice that the Web is dominated by semi-literate "screenagers" who won't read more than two sentences in a row is grossly exaggerated, and probably irrelevant to you and your audience anyway. You do not need to "dumb down" your content or shave it to a meaningless skeleton. Just be aware that readers will typically want to print longer pages or more complex presentations to read "offline" from paper.

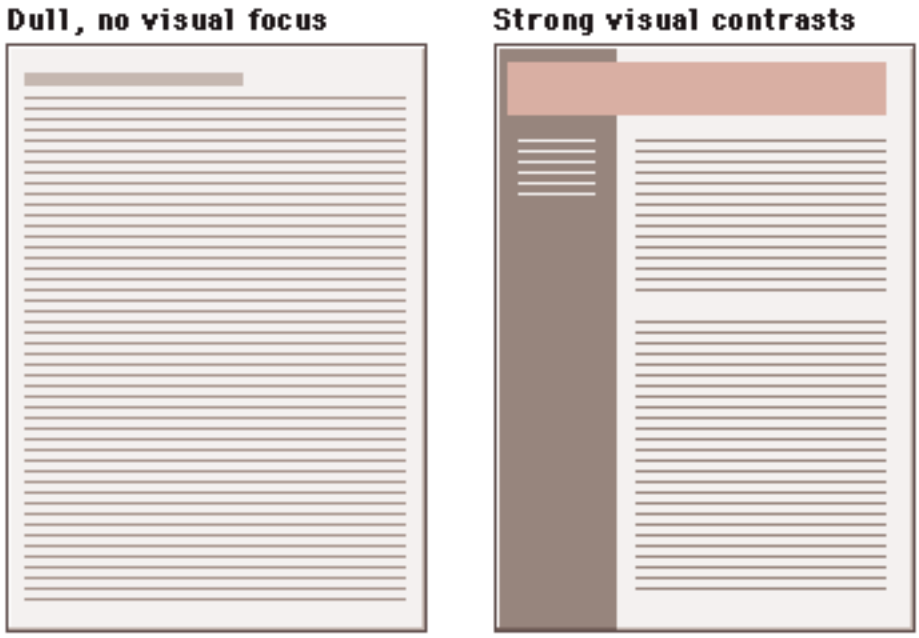
Establish a visual hierarchy

The primary task of graphic design is to create a strong, consistent visual hierarchy, where important elements are emphasized, and content is organized logically and predictably.

Graphic design is visual information management using the tools of layout, typography, and illustration to lead the reader's eye through the page. Readers see pages first as large masses of shape and color (see below), with foreground elements contrasted against the background field. Only secondarily to they begin to pick out specific information, first from graphics if they are present, and only afterward do they start parsing the "harder" medium of text and begin to read individual words and phrases:



Thus the overall graphic balance and organization of the page is crucial to drawing the reader into your content. A dull page of solid text will repel the eye as a mass of undifferentiated gray, but a page dominated by poorly designed or overly bold graphics or type will also repel sophisticated users looking for substantive content. What you want is an appropriate balance that attracts the eye with visual contrast:



Proportion and "appropriateness" are the keys to successful design decisions, but those things can only be determined within the context of your overall purpose in developing a Web site, by the nature of your content, and most importantly, by the expectations of your audience.

Direct the reader's eye

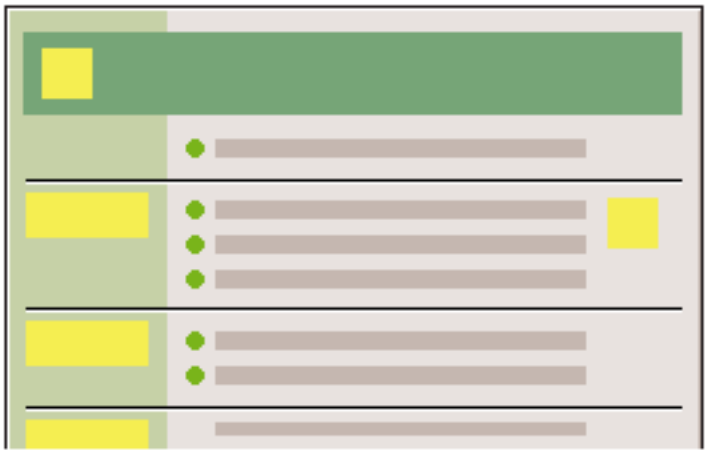
In the West readers of English read from left to right, and from the top of the page to the bottom. This fundamental visual axis dominates most design decisions, and is the basis for most conventional graphic design of print publications. In page layout the top of the page is always the most dominant location, but on Web pages the upper page is especially important, because the top four inches of the page is all that is visible on the typical 14 to 16 inch office computer monitor.

Subtle pastel shades of colors typically found in nature make the best choices for background or minor elements, especially if you are new to graphic design and color selection. Avoid bold, highly saturated primary colors except in regions of maximum emphasis, and even there use them cautiously. Type must always contrast sharply with any background color. If you have a

dramatic or complex graphic scheme in mind, hire a professional graphic designer to execute it. If you are not a designer and must do things yourself, keep everything conservative, conventional, and simple.

Graphic distractions

Beware of graphic embellishments. Horizontal rules, graphic bullets, icons, and other visual markers have their occasional uses, but apply each sparingly (if at all) to avoid a patchy and confusing layout. The same applies for the larger sizes of type on Web pages. One reason professional graphic designers are so impatient with HTML is the grotesquely large type sizes displayed by most Web browsers when using the "H1" and "H2" header tags. The tools of graphic emphasis are powerful, and should be used only in small doses for maximum effect. Overuse of graphic emphasis leads to a "clown's pants" effect where everything is garish and nothing is really emphasized:



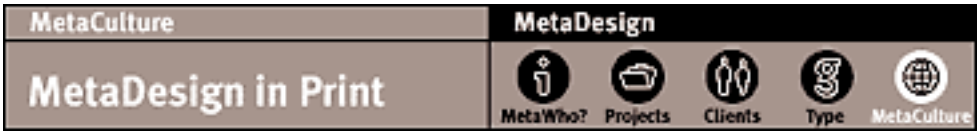
Be consistent

Establish a layout grid and a style for handling your text and graphics, then stick with it to build a consistent rhythm and unity across all the pages of your site. Repetition is not boring; it gives your site a consistent graphic identity that reinforces a distinct sense of "place," and that makes your site more memorable. A consistent approach to layout and navigation allows readers to quickly adapt to your design, and to confidently predict the location of information and navigation controls across the pages of your site.

If you choose a graphic theme, use it throughout your site. Metadesign's home page banner (below) set s the graphic theme for the site, and introduces distinctive typography and a set of navigation icons:

Graphic has been reduced from the original size. www.metadesign.com/

This is a banner at the top of an interior page in Metadesign's site. Note how the typography and icon theme is carried through to all interior banners. There is no confusion about who's site you are navigating through:



Graphic has been reduced from the original size. www.metadesign.com/

"Style"

Don't set out to develop a "style" for your site, and be very careful about simply importing the graphic elements of another Web site or print publication to "decorate" your pages. The graphic and editorial style of your Web site should evolve as a natural consequence of consistent and appropriate handling of your content and page layout.

References

Hurlburt, A. 1977. *Layout: The design of the printed page.* New York: Watson-Guptill.

Meggs, P. B. 1989. *Type and image: The language of graphic design.* New York: Van Nostrand Reinhold.

Metadesign.

Mok, C. 1996. *Designing business: multiple media, multiple disciplines.* San Jose: Adobe Press.

Spiekermann, E., and E. M. Ginger. 1993. *Stop stealing sheep & find out how type works.* Mountain View, CA: Adobe Press.

Tufte, E. R. 1990. *Envisioning information.* Cheshire, CT: Graphics Press.

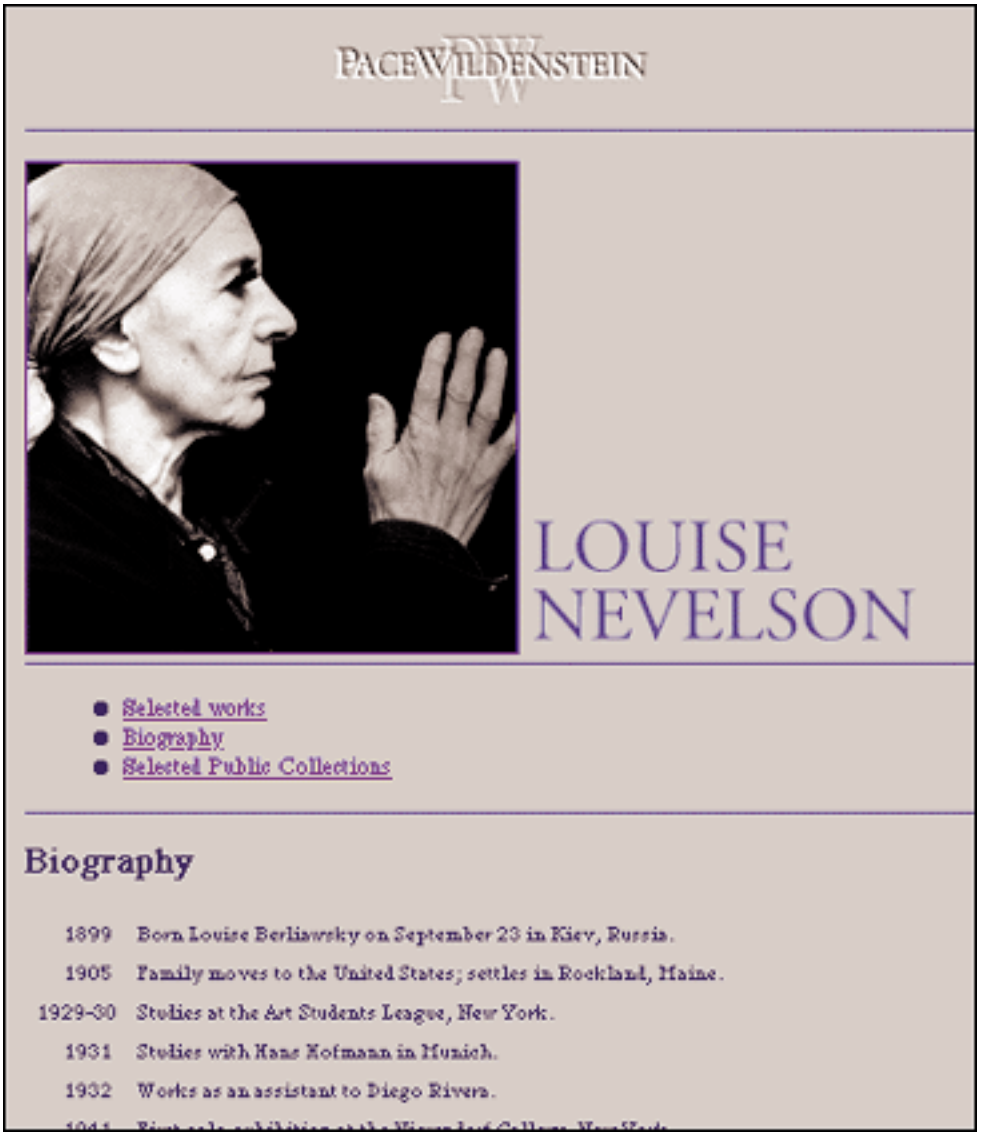
White, J. V. 1988. *Graphic design for the electronic age.* New York: Watson-Guptil.

Wilson, A. 1974. *The design of books*. Salt Lake City: Peregrine Smith, Inc.

Web page design is largely a matter of balancing the power of hypermedia Internet linkages against the ability to imbed graphics and motion media within networked Web pages. Some home or menu pages function more like the covers of books or magazines. The idea is to draw the user into the material with a combination of text descriptions and interesting graphics related to the subjects:

Graphic has been reduced from the original size. www.apple.com

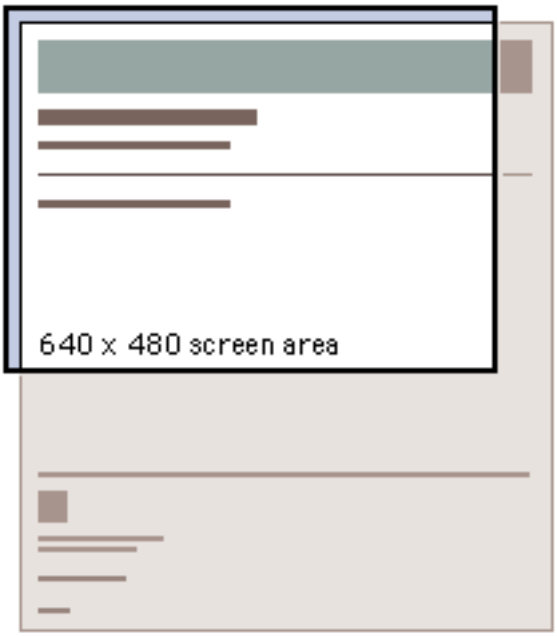
The most efficient designs for general (mostly modem-based) Internet audiences tend to use careful layouts of text and links with relatively small graphics. These pages load into viewers quickly, even when accessed from 28.8 kbps modems over SLIP or PPP lines, yet these pages still achieve a substantial graphic impact. This is razorfish's elegant but minimal layout design for the Pace-Wildenstein Gallery:



Graphic has been reduced from the original size. http://www.pacewildenstein.com/

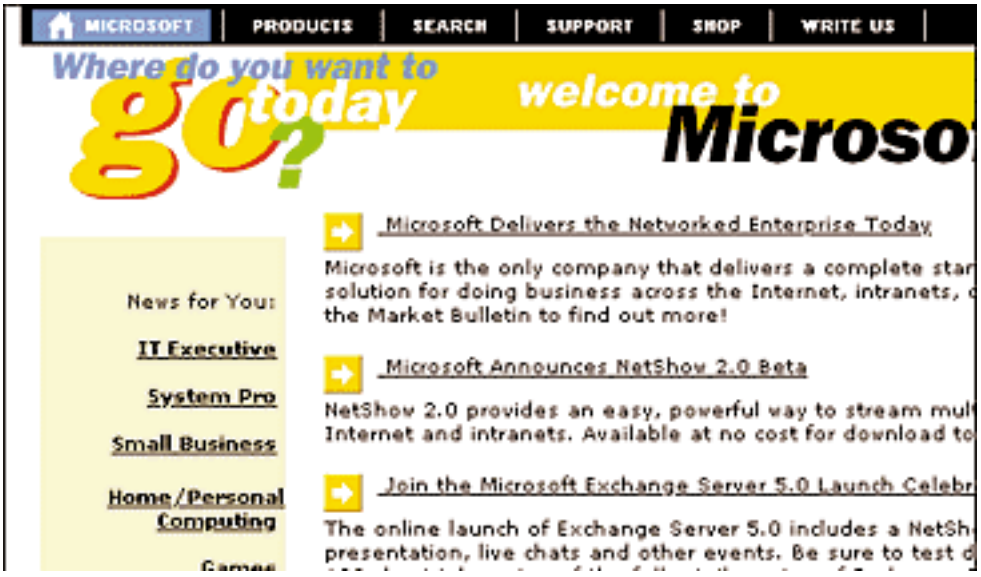
The screen is smaller than a printed page
While Web pages and conventional documents share many graphic, functional, and editorial similarities, the computer screen is the primary delivery site for web-based information, and the computer screen is very unlike the printed page. Graphic designers often create page grids that look great on their extra-large monitors, forgetting that most users cannot display more than about half of the typical Web page at any one time, and only 10% of Web surfers ever scroll the page.

Width of page graphics
Computer screens are typically smaller than most books or magazines. A very common mistake in Web design is spreading the horizontal width of your page graphics beyond the area most viewers can fit on their 14-15 inches display screens.



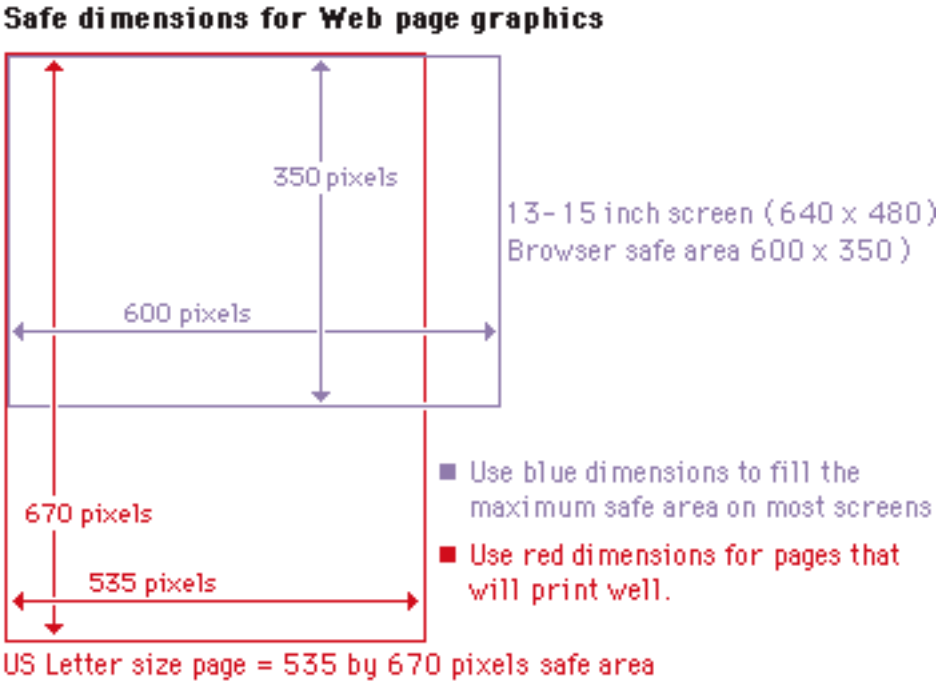
Graphic dimensions for web pages

Web page graphics should not be more than 535 pixels wide or more than about 320 pixels high, or the graphic will be too wide to print on letter size or A4 paper. Even when your readers have large display screens, the typical Netscape or Internet Explorer window still defaults to a window width designed for smaller monitors. Microsoft's otherwise excellent home page is too wide for many standard office monitors:



Graphic has been reduced from the original size. www.microsoft.com

The following size recommendations are based on the typical dimension of a Web browser on a 14 inch or 15 inch Macintosh or Windows 95 screen:



Design grids for HTML pages

A Web page can be almost any length, but you've only got about 30 square inches at the top of your Web pages to capture the average reader, because that is all they will see as your page loads. If all you offer is a big, slow-to-load graphic, many casual readers will leave before they ever see the rest of your Web site.

We have designed a page background graphic that shows the safe areas for 640 by 480 pixels screens, and also shows approximate page boundaries for printing Web pages. Note that the boundaries are only approximate, as font sizes vary considerably across different computing platforms and operating systems.

Page with grid background

This page shows the same background graphic placed on the page, where you can copy it for your own use. Follow the procedures for your particular browser in copying images. Users of the Windows version of Netscape should click on the graphic with the right mouse button to get a menu of options for copying and saving the graphic. Mac users of Netscape 2.0 or later should click and hold down the mouse button until the pop-up menu appears.

Consistency and predictability are essential attributes of any well-designed information system, aiding users in identifying the origin and relationships of World wide Web pages, providing consistent and predictable access to interface and page elements, and a consistent graphic design scheme. The design grids that

underlie most well-designed paper publications are no less necessary in designing electronic documents and on-line publications, where the spatial relationships between on-screen elements is constantly shifting in response to user input and system activity.

Clown's pants

Current implementations of the Hypertext Markup Language (HTML) do not allow the flexibility or control that graphic designers routinely expect from page layout software or conventional multimedia authoring tools. However, the HTML markup language can be used to create complex and highly functional information systems if it is used carefully. When used inappropriately or inconsistently the typographic controls and inlined graphics of World Wide Web (Web) pages may result in a patchy, confusing jumble, without any apparent visual hierarchy of importance. This unfortunate "clown's pants" effect of haphazardly mixed graphics and text results in decreased usability and legibility, just as it does in paper pages. A carefully organized design grid that is consistently implemented across a range of pages will aid your users in quickly finding the information they want, and will increase the reader's confidence that they are using a thoughtfully organized collection of information:

References

Apple Computer, Inc.

Hurlbutt, A. 1978. *The grid.* New York: Watson-Guptill.

Microsoft Corporation

Pace-Wildenstein Gallery

razorfish

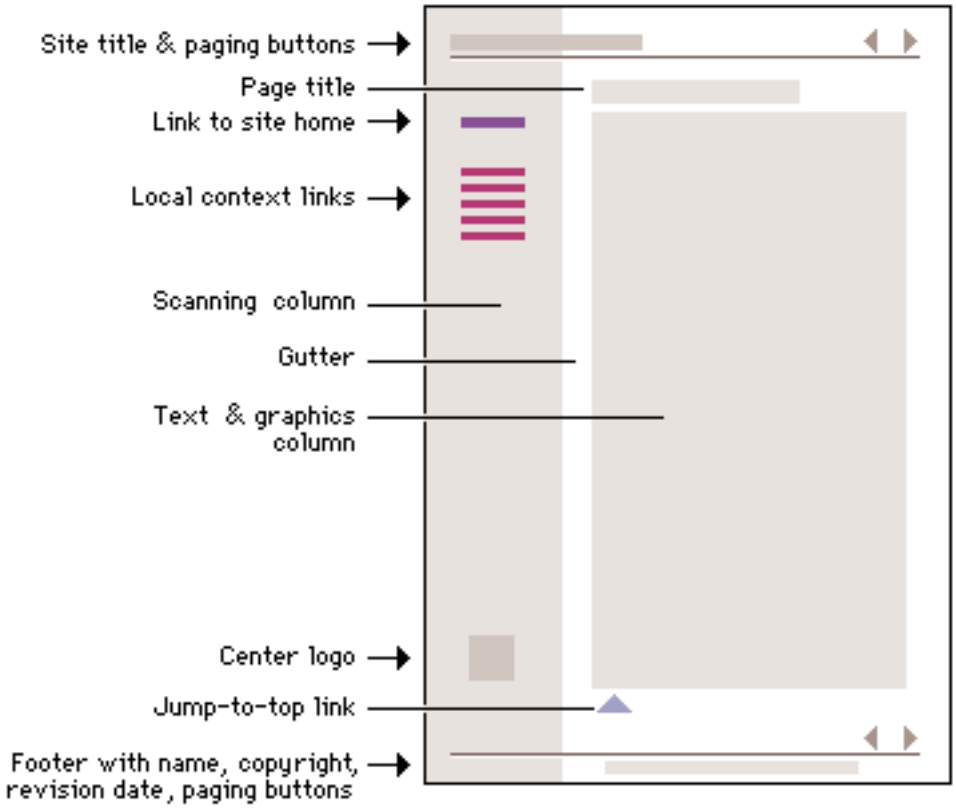
White, J. V. 1988. *Graphic design for the electronic age.* New York: Watson-Guptill.

There is no single design grid system that is appropriate for all Web pages. The first consideration in a Web design project is to establish the basic layout grid for your pages. With this graphic "backbone" you establish how the major blocks of type and illustrations will regularly occur in your pages, and set the placement and style guidelines for major screen titles, subtitles, and navigation links or buttons. To start, gather representative examples of your text, along with some graphics, scans, or other illustration material, and experiment with various arrangements of the elements on the page. In larger projects it isn't possible to predict how every particular combination of text and graphics will interact on the screen, but examine your Web layout "sketches" against both your most complex and least complex pages.

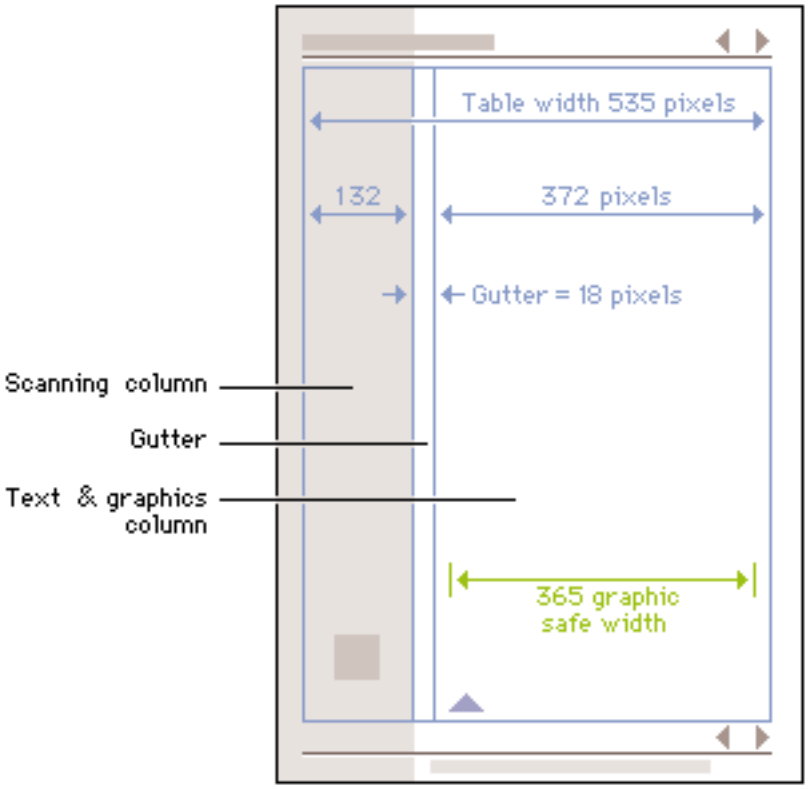
The goal is to quickly establish a consistent, logical screen layout, one that allows you to quickly "plug in" text and graphics for each new page without having to stop and re-think your basic design approach for every new page. Without a firm underlying design grid, your project's page layout will be driven by the problems of the moment, and the overall design of your Web system will look patchy and visually confusing.

Analyzing page grids

When we designed this style manual we used a basic page grid that incorporates an image map menu at the top and bottom of every page incorporating paging buttons. A "scan column" along the left of the page does two jobs: it provides space for local links to related material, and also gives visual relief by narrowing the right text column to about 60 - 70 characters per line. This diagram shows the major repeating components of the style manual pages:



Here we show the "invisible" table (BORDER="0") that underlies the column structure of the page, and the critical page dimensions:



We chose 535 pixels as the maximum dimension for the page layout because that is the widest table that will print on standard letter size or A4 paper (although, given variations in Web broswers, fonts, and laserprinters, some slight cropping may occur.). With a few exceptions, all graphics for this manual were designed to fit within the 365 pixel "safe area" of the text column. If you view the source code for these style guide pages you will see that the table structure we finally ended up with is quite complex. The example page below shows a similar but highly simplified table-based layout with a scan column and a text colum. For illustrative purposes we set the table border to "1" so you can see the edges of the table:

Simple table-based page layout example.

To modify this example for your own use, click the link to open the page, then use your browser's "View source code" option to view and copy the HTML code.

The best measure of home page efficiency

How many links are there in the top four inches of your menu page designs? The average computer display sold today is only about 14 to 16 inches in diagonal measurement, and shows a "desktop" of about 640 by 480 pixels. That should tell you that the top four inches of your Web home page is the most crucial area in your site because that's the only area you can be sure most users will see when they hit your home page. Many sites surrender to the giddy thrills of large home page graphics, forgetting that the a Web page is not just a visual experience it has to function efficiently to retain its appeal to the user. A complex home page graphic that takes forever to download, doesn't fit on the average reader's screen, and offers little or no functionality will repel most Web users.

Remember that Web pages must be downloaded to the user, and that the page only gradually builds its graphic impact. The best measure of the efficiency of a page design is the number of options available within the top four inches of your page. A big, bold graphic may tease the casual Web surfer, but if it takes the average reader a full minute to download the top of your page, and there are no links to be seen until the user scrolls down the page (causing even longer delays), then you may have lost a big part of your audience before you even get to offer them any links to the rest of your site.

Think in screens of information, not pages

Always base your page header design on what the average reader with the average display monitor will see within the first screen of information. The most effective Web page headers incorporate a combination of graphics and interactive links, most often in the form of an imagemap. The imagemap banners at the tp of the pages in the Yale C/AIM Web site are designed to deliver graphic impact to the page while offering the user six links within the top one and a half inches of the page:

Graphic has been reduced from the original size. www.med.yale.edu/caim/

Consistent graphic identity

One of the major purposes of careful graphic design is to provide a unique visual identity to your Web site. A consistent "signature" graphic and page layout allows the reader to immediately know what the main point of the document is, and what (if any) relationship the page may have to other pages. Graphics used within headers can also signal the relatedness of a series of Web pages. Unlike print documents, designers of Web systems can never be sure what (if any) other pages the reader has seen before linking to the current page. Sun Microsystem's many corporate Web sites all include a signature header graphic that is also an imagemap with basic navigation links included:

Graphic has been reduced from the original size. www.sun.com

Even if you choose not to use graphics on your pages, the header area of a Web page should contain a prominent title at or very near the top of the page. Graphics placed above the title line should not be so large that they force the title and introductory text off the page on standard office-size monitors (640x480 pixels). In a related series of documents there may also be subtitles, section titles, or other text elements that convey the relationship of the currently visible document to others in the series. To be effective, these title elements must be carefully standardized across all of the pages in your site.

Page footers

Page footers should always carry basic information about the origin and age of the page. Every Web page needs to bear this basic information, but this repetitive and prosaic information often does not deserve the prominence of being placed at the top of the page. Most Web pages are bigger than the average display screen, so that by the time most readers have scrolled to the bottom of the Web page the navigation links you might have provided at the top of the page are no longer visible. Well-designed page footers usually offer the user a set of links to other pages.

The pages in Sun Microsystem's site all cary a distrinctive footer graphic that gives a consistent visual and functional identity:

Graphic has been reduced from the original size. www.sun.com

References

Visual contrast and page design

Good typography depends on the visual contrast between one font and another, and the contrast between text blocks and the surrounding empty space. Nothing attracts the eye and brain of the viewer like strong contrast and distinctive patterns, and you only get those attributes by carefully designing them into your pages. If you make everything bold, then nothing stands out and you end up looking as if you are SHOUTING at your readers. If you cram every page with dense text, readers see a wall of gray and their brains will instinctively reject the lack of visual contrast. Just making things uniformly bigger doesn't help at all. Even boldface fonts become monotonous very quickly, because if everything is bold then nothing stands out "boldly."

Use the major HTML headings sparingly. One alternative to overly bold HTML headers is to use the physical style controls of HTML to make text bold or italic without increasing the font size. However, you should understand that there are some disadvantages to using physical styles to control the typography of your Web pages. The HTML heading tags (H1, H2, etc.) are designed to identify important titles and subtitles in your text, and are only incidentally meant to change the visual display of the titles. If you use the "FONT SIZE" tags in Netscape, use or physical styles like "BOLD" then automatic indexing and text analysis programs will have a difficult time analyzing your web documents.

Visual logic versus structural logic

The framers of the original HTML standards were physical scientists who wanted a standard means to share documents with minimal markups aimed at revealing the logical structure of the information. Since they had little interest in the exact visual form of the document, no precise typography and page formatting is possible in current implementations of HTML. In focusing solely on the structural logic of the HTML document, the framers of the Web ignored the need for the visual logic of sophisticated graphic design and typography.

The standards organization responsible for codifying the HTML language is responding the widespread complaints of graphic designers that the heading tags in Web documents often produce clunky, over-large titles and subtitles. Through style sheets and new font control tags future versions of HTML will sson allow you to specify what size font each header level will produce in each Web page. Thus you will be able to produce more sophisticated typography without giving up the substantial advantages of using the conventional HTML header tags.

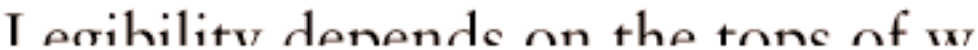
Type and legibility

We read primarily by recognizing the overall shape of words, not by parsing each letter and then assembling a recognizable word:

Avoid all-uppercase headlines they are much harder to read, because words formed with capital letters are monotonous rectangles that offer few distinctive shapes to catch the reader's eye:

Legibility depends on the tops of words

Your choice of uppercase or lowercase letters can have a dramatic effect on legibility. In general, use downstyle (capitalize only the first word, and any proper nouns) for your headlines and subheads. Downstyle headlines are more legible, because we primarily scan the tops of words as we read:



Notice how much harder it is to read the bottom half of the same sentence:

If you use initial capital letters in your headlines you disrupt the reader's scanning of the word forms:

References

Bringhurst, R. 1992. *The elements of typographic style.* Washington: Hartley and Marks.

Siegel, D. 1996. *Creating killer web sites.* Indianapolis: Hayden Books.

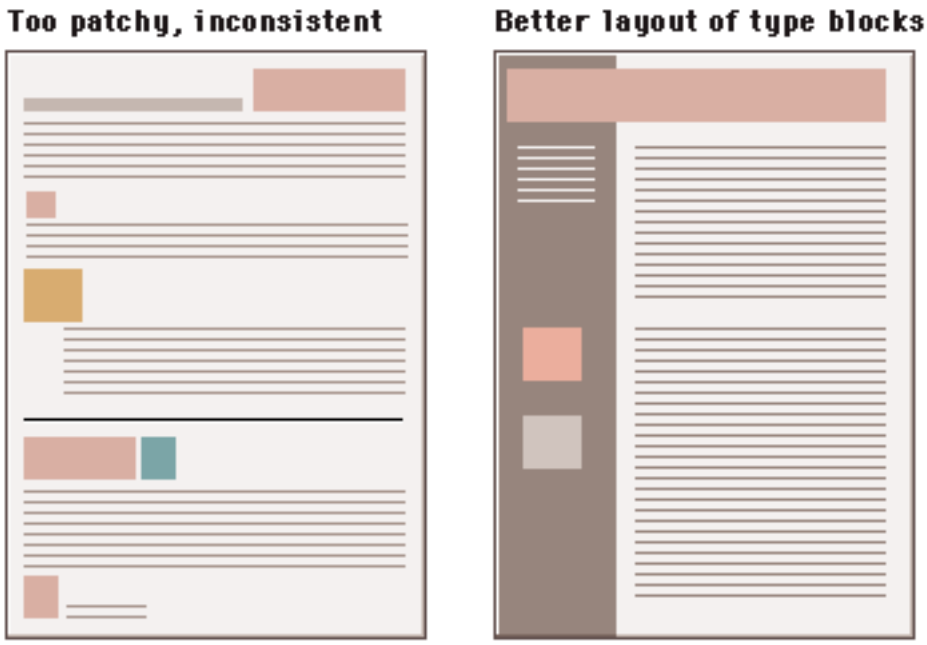
www.killersites.com

Spiekermann, E., and E. M. Ginger. 1993. *Stop stealing sheep & find out how type works.* Mountain View, CA: Adobe Press.

typoGRAPHIC A concise, elegant essay on typography and letterforms from razorfish/bluedot.

Pattern and page design

When your content is mostly text, typography is the tool you use to "paint" patterns of organization on the page. The first thing your reader sees is not the title or other details of the page, but the overall pattern and contrast of the page. The reader's eye scans the page first as a purely graphic pattern, then begins to track and decode type and page elements. The regular, repeating patterns established through carefully organized pages of text and graphics help the reader to quickly establish the location and organization of your information, and increase the overall legibility of your pages. Patchy, heterogeneous typography and text headers makes it difficult for the user to see major patterns quickly, and makes it almost impossible to for the user to quickly predict where information is likely to be in located in unfamiliar documents:



Settle on as few heading styles and subtitles as are necessary to organize your content, then use your chosen styles consistently. The fact that HTML provides six levels of headings doesn't mean that you should ever use six levels of headings in a single page. This whole manual of over 60 Web pages uses only two headers; an H2-level page title, and boldface subtitles.

Manipulating text blocks

Text on the computer screen is hard to read because of the low resolution of today's computer screens, but also because the layout of most Web pages violates one of the most basic rules in book and magazine typography: the lines of text in most Web

pages are much too long to be easily read. Magazine and book columns are narrow for physiologic reasons: at normal reading distances the eye's span of movement is only about 8 cm (3 inches) wide, so designers try to keep dense passages of text in columns no wider than reader's comfortable eye span. Wider lines of text require the readers to move their heads slightly, or strain their eye muscles to track over the long lines of text. Unfortunately most Web pages are almost twice as wide as the viewer's eye span, so extra effort is required to scan through those long lines of text. If you want to encourage your Web site users to actually read a document online (as opposed to printing it out for later reading), consider using the "BLOCKQUOTE" or "PRE" HTML tags to shorten the line length of text blocks to about half the normal width of the Web page.

The pages in this manual are laid out using an invisible 2-column table (BORDER="0") to restrict the text line length to about 40 to 60 characters per line. The exact character count is difficult to predict because of the way different browser software and different operating systems display type sizes. In conventional print layout columns of 30 to 40 characters per line are considered ideal, but this seems too sparse to our eyes for Web page layout.

References

White, J. V. 1988. *Graphic design for the electronic age.* New York: Watson-Guptil.

Wilson, A. 1974. *The design of books*. Salt Lake City: Peregrine Smith, Inc.

The content of this style manual is all contained in invisible tables to allow us control over the layout of the pages. Without tables, text and graphics are essentially poured onto the user's screen, with the actual layout of pages depending entirely on the width and height of the browser window. All of the issues of legibility, readibility, and style that we have discussed in this manual rely on the ability to position words, images, and screen elements on the "page" in a way that adheres to established typographic conventions. Because of the limitations of HTML, the only layout tool for site designers at this time is tables.

Using tables for page layout

Tables are currently the only HTML option for page layout. If you simply place a chunk of text on a page, the length of the lines is determined by the dimensions of the viewer's browser window. When the user resizes their window, the text reflows to fill the new space. Though some may consider this a "feature," it actually hinders the user's experience with the content. The conventions of print give us a comfortable place to access content. Without some adherance to these standards you may discomfit and ultimately lose your readers.

To avoid this use tables to define the areas of your pages. Use table cells to create margins, put your text in table cells to limit the line length (ideally 10 to 12 words on a line), and use cells to position elements on the page.

Cell attributes and table dimensions

The behaviour of a table depends largely on how its cells are defined. For the purposes of page layout you should define cell widths with absolute values. Additionally, the cell should contain a single-pixel GIF equal to the width of the cell to make sure that the table dimensions do not change when the browser window is resized.

Page with table examples

No borders, please!

When we talk about tables we are not speaking of the beveled beauties that HTML offers for the presentation of tabular content. We are using tables to get around the limitations of HTML, and we are using them in ways in which they were not intended. These are invisible tables whose sole purpose is to give us control over page elements, so be sure to set BORDER="0".

While we're on the subject, table borders are ugly and unnecessary even in the context of the tabluar materials they were intended for. It is much cleaner to use spacing, alignment,

and indents to delimit tabluar information.

Lorem ipsum	Lorem ipsum dolor sit amet, consectetuer adipiscing elit, sed diam nonummy nibh euismod tincidunt ut laoreet dolore magna aliquam erat volutpat. Ut wisi enim ad minim veniam, quis nostrud exerci tation ullamcorper suscipit lobortis nisl ut aliquip ex ea commodo consequat.
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Gutters
In print the space between columns is referred to as a gutter. You can use tables to create gutters, either through 1) adding a cell that serves as the gutter, or 2) by using the cellpadding (space between cell contents and cell) or 3) cellspacing (space surrounding cell) attributes.

1		Table with cell gutter

2	Table with cellpadding = 8

3	Table with cellspacing = 8

References

Siegel, D. 1996. *Creating killer web sites*. Indianapolis: Hayden Books. www.killersites.com

Determining the proper length for any particular World Wide Web (Web) page requires balancing four major factors:

- The relationship between the page and screen size.
- The particular content of your documents.
- Whether the reader is expected to browse the content online, or to download the documents for later reading.
- The bandwidth available to your target audience. (e.g., how fast is their connection to the Web?)

Relationships between the document length and the screen
Many human interface researchers and designers of graphic user interfaces have noted the disorienting effect of scrolling on computers screens. This loss of local context within scrolling computer screens is particularly troublesome when basic navigational elements like linkages to other local pages in the Web site disappear off-screen as the user moves through very long pages. This argues for navigational Web pages (home pages and menus in particular) that contain no more than about one to two 640x480 screens worth of information, and which feature local navigational links at both the beginning and end of the page layout. Long Web pages require the user to remember too much information that is currently scrolled off the screen; users easily lose a sense of context when the navigational buttons or major links are not visible:

In long Web pages the user must depend on the vertical scroll bar slider (the little box within the scroll bar) to navigate. In most graphic interfaces (Macintosh, Windows 3.1) the scroll bar slider is also fixed in size, and provides little indication of the document length relative to what's currently visible on the screen, so the user gets no visual cue to page length. In very long Web pages small movements of the scroll bar can completely change the contents of the screen, leaving no familiar landmarks to orient by. This gives the user no choice but to crawl downward with the scroll bar arrows, or risk missing sections of the page.

However, long Web pages are often easier for managers to organize, and for users to download. Web site managers don't have to maintain as many links and pages with longer documents, and users don't need to download multiple files to collect information on a topic. Long pages are particularly useful for providing information that you don't expect users to read online (realistically, that should include any document longer than two printed pages). If the Web pages get too long, or contain too many inline graphics, the pages can end up taking too long to download. Very large Web pages with lots of graphics can also overwhelm the RAM memory limitations of the Web browser.

Mirror the structure of your content

It makes sense to keep closely related information within the confines of a single Web page, particularly when you expect the user to print or save the text. Keeping the content all in one place makes printing or saving easier. However, once you get beyond about four screens worth of information the user must scroll so much that the utility of the online version of the page begin to deteriorate. Long pages often fail to take full advantage of the linkages available in the Web medium.

If you want to provide both a good online interface for pages and easy printing or saving of the content:

- Divide the page up into chunks of two to three printed pages worth of information, including inlined graphics or figures. Use the power of hypertext links to take full advantage of the Web medium.
- Provide a link to a separate file that contains the full-length text combined into one page, designed so the reader can print or save all the related information in just one step. Don't forget to include the URL of the online version within the text of that page so users can find updates and correctly cite the page source.

Modular design of online collections of pages

One of the primary advantages of online documents is that they can be rapidly updated. In practice the editor or "webmaster" of a large Web site is constantly swapping in new updated files for old ones. In well-designed modular system pages covering particular topics can be updated quickly without needing to change large sections of information or re-format complex pages. The page length may increase in a modular system, but the URL of each topic page remains the same, regardless of how long the page grows. Thus modular systems are better when you want to give you readers a sense of stability (the URLs of major pages remain constant) , even while your Web site expands. The concept is essentially similar to the loose-leaf procedural manuals most organizations use to keep paper documents reasonably up to date by replacing old sections for new, except that Web systems offer much more flexible and economical means of keeping information current.

In general, you should favor shorter Web pages for:

- Home pages, and menu or navigation pages elsewhere in your site.
- Documents to be browsed and read online.
- Pages with very large graphics.

In general, longer documents are:

- Easier to maintain (they are all in one piece, with fewer links).
- More like the structure of their paper counterparts (not chopped up).
- Much easier for users to download and print.

References

Horton, W. K. 1994. *Designing and writing online documentation, 2nd edition.* New York: Wiley.

Mullet, K., and D. Sano. 1995. *Designing visual interfaces.* Englewood Cliffs, NJ: SunSoft Press-Prentice Hall.

Norman, D. A. 1993. *Things that make us smart.* Reading, MA: Addison-Wesley.

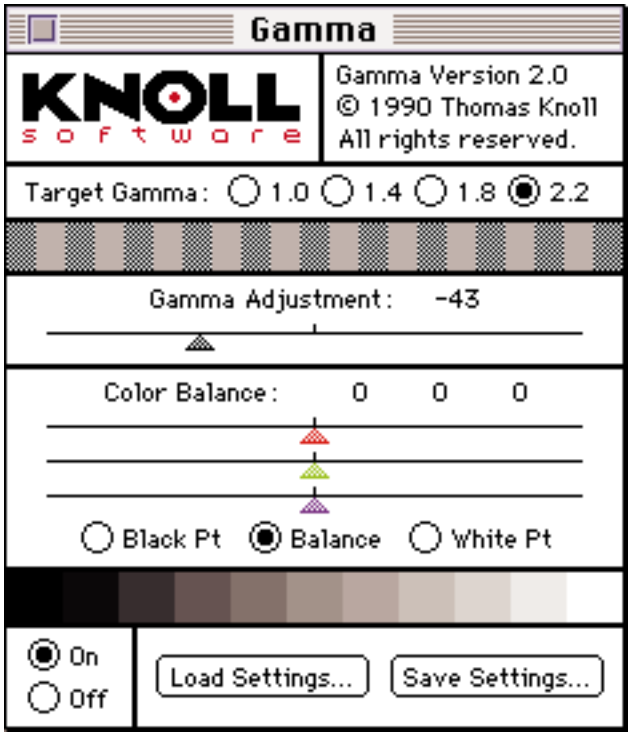
Shneiderman, B. 1992. *Designing the user interface: Effective strategies for effective human-computer interaction. 2nd ed.*, Reading, Mass.: Addison-Wesley.

Monitor gamma settings

In computer imaging and display screens "gamma" refers to the degree of contrast between the mid-level gray values of an image. The technical explanations of gamma are irrelevant here the visual effect of changing gamma values is easy to see. If you have a copy of Adobe Photoshop, open an image with an average range of colors and contrasts and use the "Levels" control to change the gamma settings (see the Photoshop manual for details). Images will change noticeably with even minor changes in gamma settings. Gamma considerations are particularly important if you are displaying images with very long gray scales (like medical diagnostic images or fine black and white photography) or images with critical color values (like art history images or clinical medical photographs).

The default gamma settings for Macintosh (1.8 target gamma) and Windows monitors (2.2 target gamma) are quite different, and this can lead to unpleasant surprises when you first see your images displayed on "the other" platform. Mac users will see their images get much darker and more contrasty on Windows displays; Windows users will see their images as flat and washed out on Mac displays. Most Web designers opt for a middle-ground solution, lightening images slightly if they work on the Macintosh; darkening slightly and adding a little more contrast if they work in Microsoft Windows.

If you use Adobe Photoshop you can use the "Gamma" Control Panel that ships with Photoshop to experiment with your monitor gamma settings. To simulate the windows display on a Macintosh, set the target gamma to 2.2 and the gamma adjustment slider to "-43", then save those settings.



In the Windows version of Photoshop the gamma control only applies to images **within Photoshop windows**, not to the global display environment as it does on the Macintosh. The default gamma setting for the Windows version of Photoshop is 1.8 (same as the Mac). To see how your graphics may look once they are out of Photoshop and into your Windows Web browser, use the gamma control in Windows Photoshop to boost the Photoshop display gamma to 2.2 (to match the normal Windows operating system gamma).

Default text sizes

In general, screen type sizes in Windows (3.1, Win95, WinNT) appear about two sizes larger than the equivalent Macintosh versions. Thus a line of 12 point Times type on a Macintosh looks more like 14 points in Times New Roman on a windows machine. If you don't have ready access to a machine with "the other" operating system, use the "FONT SIZE" HTML tag at the top of your page to globally change the type size for a quick preview:

- Mac users should try <FONT SIZE="+2">
- Windows users should try <FONT SIZE="-2">

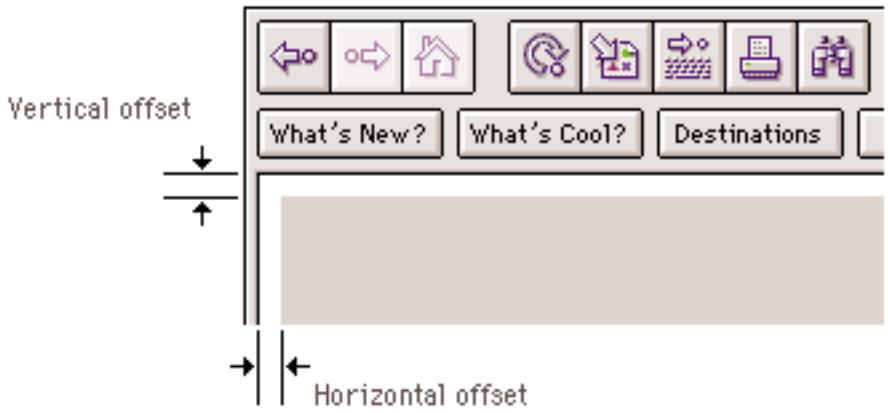
Browser variations

Every Web browser interprets HTML tags a little differently. Tables, forms, graphic positioning and alignment tags will all work a bit differently in each brand or version of Web browser. Normally these subtleties might pass unnoticed, but in very

precise or complex Web page layouts they can lead to some nasty surprises. At this writing the two main Web browsers are Netscape Navigator 3.0 and Microsoft Internet Explorer 3.0 (2.0 on Macs). Both now support HTML 3.0, the original 1995 "Netscape extensions" to HTML, plus Javascript, Java, and share a (mostly) compatible plug-in architecture. But never trust the implementation of any of these advanced features until you have seen your Web pages displayed and working reliably in each brand of browser.

Graphics offset variations

Beware of trying to get a graphic imbedded on your page to line up precisely with a page background image. Offset variations make it a losing cause. The offset is the built-in margin that Web browsers automatically create between the edge of the browser window and the graphics you place on your page:



If the browser offset was fixed and consistent across browser brands and various hardware platforms the problem would be manageable, but unfortunately every browser seems to give a slightly different dimensions to the vertical and horizontal offsets. Thus even if you have perfectly lined up your foreground and background images in your particular brand and version of Web browser, you cannot count on the images lining up on someone else's screen. Even within one company the offset is inconsistent; the different platform versions of Netscape all give slightly different offsets.

Fortunately Microsoft recognized the problem and has added support for two new HTML tags to Microsoft Explorer 3.0. The "LEFTMARGIN" and "TOPMARGIN" tags allow direct control over margin offsets, and Netscape has apparently committed to support these tags in the 4.0 version of Netscape Navigator. See Siegel (1996) or Weinman (1996) for detailed discussions of these topics.

References

Apple Computer, Inc. 1992. *Macintosh human interface guidelines.* Reading, MA: Addison-Wesley.

Microsoft Corporation. 1992. *The Windows interface: An application design guide.* Redmond, WA: Microsoft Press.

Siegel, D. 1996. *Creating killer web sites.* Indianapolis: Hayden Books.
www.killersites.com

Weinman, L. 1996. *Designing Web graphics.* Indianapolis: New Riders.
www.lynda.com

Web pages share similarities to individual pages in a print publications, but because Web pages may be accessed directly with no preamble, Web pages must be more independent than print pages. Too many Web pages end up as isolated fragments of information, divorced from the larger context of their parent Web sites through lack of essential links, and the simpler failure to properly inform the reader of their contents.

The best overall publication guide we know of is an information design classic, the *Xerox Publications Standards* manual. The Xerox manual has formed the basis for countless company and institutional publications standards manuals. We think the best writing guide is not Strunk and White, but William Zinsser's *On Writing Well*. Zinsser's book is better on all counts, and contains much more practical advise for writing in different publication formats and for different audiences.

Titles and subtitles

Forget icons, banner graphics, bullets, horizontal rules, and colored backgrounds. Editorial landmarks like titles and headers are the fundamental human interface issue in Web pages, just as they are in any print publication. A consistent approach to the titling, headlines, and subheads in your documents will aid your readers in navigating through a complex set of Web pages.

The text styles used in this manual follow suggestions from the *Xerox Publishing Standards*:

Headline style

- Bold, capitalizing the initial letters, for:
- Document titles
- Other web sites
- Titles of documents referred to within the text
- Proper names, product names, trade names

Downstyle

- Bold, capitalize first word only, for:
- Subheads
- References to other heading within the style manual
- Figure titles
- Lists

HTML and page titles

Web page titles are designated in the HTML document head section with the "TITLE" tag. the title is crucial, because the page title is often the first thing visible to users using slow Internet

connections, and because the title becomes the text for any bookmarks the reader makes to your pages. The page title should:

- Incorporate the name of your company, organization, or Web site.
- Form a concise, plainly worded reminder of the page contents.

Always think of what your page title will look like in a long list of bookmarks. Will your page title remind the reader what was interesting about your pages?

Style for online documents
Documents to be read online must be concise and structured for fast scanning. The "inverted pyramid" style used in journalism works well on Web pages as well. Get the important facts up near the top of the first paragraph where users can find them quickly. Assume readers will print anything longer than half a page rather than read the text online.

- Be concise
- Use lists where possible
- Make printing easy

Longer documents
Many types of documents (like this manual) are not well suited for the telegraphic style that works well for documents designed to be read online. Web authors often cut so much out of Web presentations that what is left would barely fill a print pamphlet. Concise writing is always better, but don't "dumb down" what you have to say there's enough dumb stuff on the Web already. Just understand that readers will want to print longer documents. Make printing easy for your readers and you can use the Web to deliver content without cutting the heart out of what you have to say.

Text for the Web
Some general points about text formatting specific to the Web:

- Excessive markup: Beware of too much markup in your paragraphs. Too many links, or **too many** *styles* **oftypeface** destroy the homogeneous, even "type color" that characterizes good typsetting.
- Link colors: If you are using custom link colors, choose colors that closely match your text color. Reading from the screen is hard enough already without having to deal with screaming orange or bilious green links.

- Use the best tool: Write your text in a good word processing program with spell-checking and search features. Transfer text to HTML only after it has been proofread.
- Style sheets: Don't use the word processor style sheets to produce "All capitals" or other formatting effects. You will lose those special formats when you convert to plain ASCII text for HTML use.
- Special characters: Don't use the "smart quotes" feature. Avoid all special characters like bullets, ligatures, and typographer's "en" and "em" dashes not supported in standard HTML text. Consult a good HTML guide book for the listing of special and international characters supported through the HTML extended character formatting.
- No auto hyphens: Never use the automatic hyphenation feature of your word processor on text destined for the Web. This may add non-standard "optional hyphen"characters to your text that will not display properly in Web browsers.

Links and language
If you are new to the Web it can sometimes be awkward to figure out where to place links within sentences. Never construct an sentence around a link phrase such as "click here for more information." Write the sentence as you normally would, and place the link anchor on the most relevant word in the sentence.

- Poor: Click here for more information on placing links within your text.
- Better: Web links are powerful, but may also cause problems if they are placed carelessly.

Parenthetic links
Links are a distraction. It is pointless to write a paragraph and then fill it full of invitations to your reader to go elsewhere. Put only the most salient and interesting links within the main body of your text. Group all minor, illustrative, parenthetic, or footnote links at the bottom of the document where they are available but not distracting.

Web references
Several companies have made excellent style manuals or publications guidelines available on the Web, including:

Sun Microsystems, Guide to Web Style, by Rick Levine.
The best of a good group; excellent, self-exemplifying advise for Web design.

Ameritech, Ameritech Web Page User Interface and Design Guidelines

Apple Computer, Apple Web Design Guide

Apple Computer, Apple Publications Style Guide

Guide to good practices for WWW authors. Margaret Issacs, University of Glasgow

Print references

Jordan, L. 1976. The New York Times manual of style and usage. New York: Times Books.

Strunk, W., and E. B. White. 1979. The elements of style, 3rd ed. New York: Macmillan.

University of Chicago Press. 1982. The Chicago manual of style. 13th ed. Chicago: University of Chicago Press.

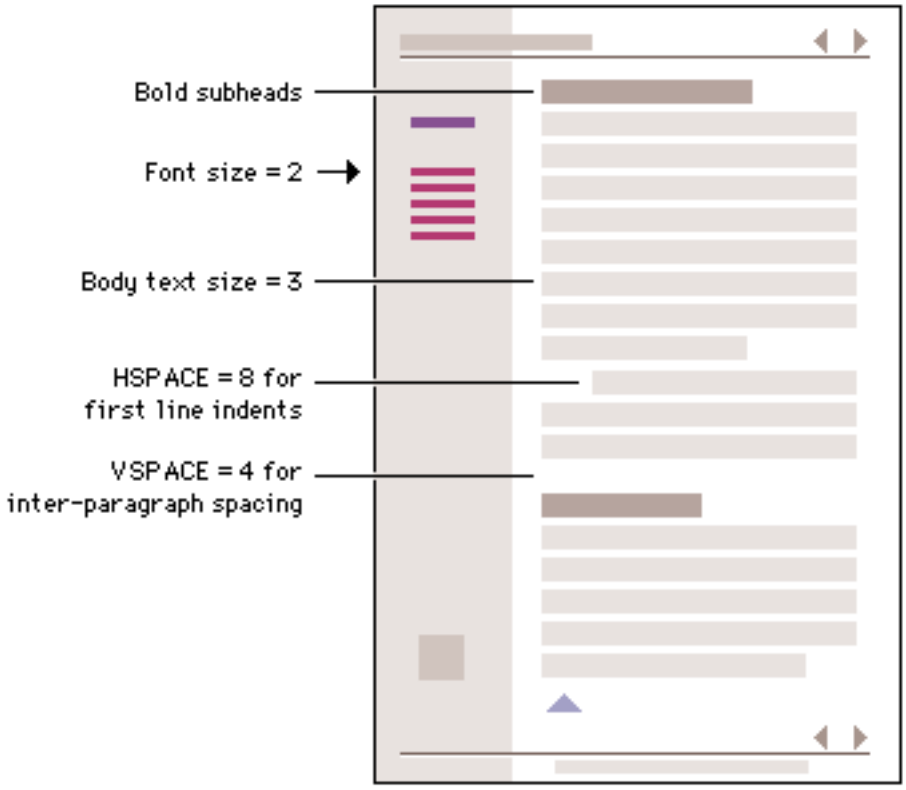
Xerox Corporation. 1988. Xerox publishing standards: A manual of style and design. New York: Xerox Press-Watson Guptill.

Zinsser, W. K. 1990. On writing well., 4th ed. New York: Harper Collins.

Just as in traditional print publishing, high-quality web sites adhere to an established set of type style settings consistently throughout the site. Consistently gives polish to a site and encourages visitors to stay by establishing an expectation on the structure of a text. If this expectation is dashed by sloppy, inconsistent formatting, visitors will not have a comfortable experience and may not return.

Style-setting

You should decide on settings such as fonts, inter-paragraph spacing, the size of subheads, and so on, and then create a style sheet to help you maintain these settings throughout your site development. This is especially critical for large sites with numerous pages for example, this style manual. At the start of this project we decided on certain type and layout settings and worked very diligently to maintain them during development.



Maintaining consistency is not as easy with the current web authoring tools as it is using page layout software like QuarkXpress or Pagemaker, but the considerations behind that functionality are applicable. It is equally important to have good, consistent layout on the screen as it is on the printed page.

Helpers

We use Bare Bone Software's BBEdit for our web site authoring. The custom selection in the "HTML Tools" palette is extremely useful for creating style sheets. You can define custom settings, and then apply them to your pages. For example, you can define an em dash ( ) to be a black square 14 pixels long and one pixel high with three pixels of vertical space, like so:

```
<IMG  SRC="resources/black.gif"  WIDTH="14"
HEIGHT="1"  VSPACE="3">
```

In the custom settings dialog box paste this tag and name it "em dash." Then every time you need to include an em dash in your text simply select "em dash" from the custom menu and this tag will be inserted.

References

Bringhurst, R. 1992. *The elements of typographic style.* Washington: Hartley and Marks.

This section contains techniques to optimize the look and efficiency of your Web page graphics. Although electronic publishing frees you from the cost and limitations of color reproduction on paper, you will still need to make some careful calculations (and a few compromises) if you want to optimize your graphics and photographs for various display monitors and current Internet access speeds.

Graphics and modems

Most of the present Web audience consists of people accessing Internet service providers via 28.8 kilobit per second (kbps) modems from their homes, offices, or remote work sites. At 28.8 kbps you only get about 3.6 kilobytes (KB) per second (remember it takes 8 bits to make each byte). This means a modest 36 KB graphic on your Web page could take 10 seconds or longer to load into the reader's Web viewer. Actual data transmission rates will vary, depending on the type of modem, the speed of your Web server, the type of Internet net connection used, and other factors, but the overall point is clear: the more graphics you use, the longer your reader will have to wait to see your page.

A full-screen graphic menu on your home page, plus background graphics could leave your modem-based readers twiddling their thumbs for a full minute or more, even if they have a state-of-the-art modem and good Internet connections. Look at your watch (or better yet, hold your breath) for a full minute, then figure out if that is the first thing you are willing to ask your users to do when they visit your Web site. A better interface strategy would be to gradually increase the graphics loading of your pages, drawing users into your site with reasonable download times. As users become more engaged with your content, they will be more willing to endure longer delays, especially if you give them notes on the size of graphics, or warnings that particular pages are full of graphics and will take longer to download.

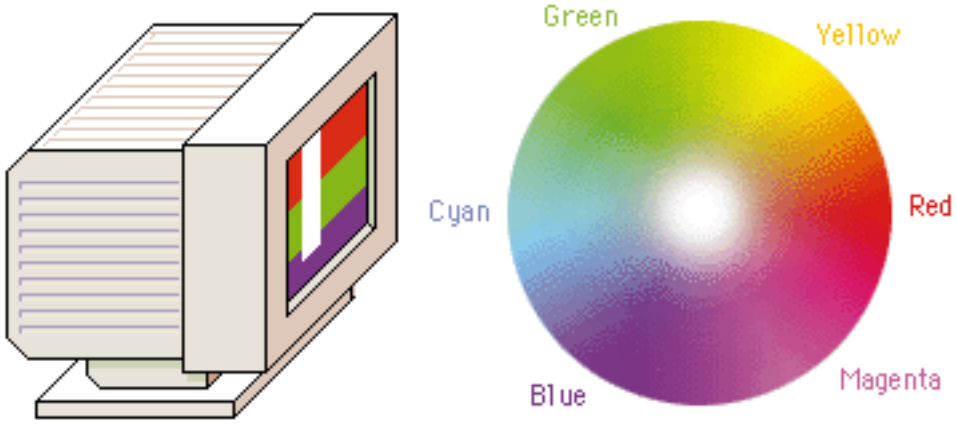
Graphics and intranets

Luckily for graphic designers, many Web sites are created primarily for educational, organizational, or commercial users who access their local intranets and the larger World Wide Web at Ethernet speeds or greater. Graphics and page performance are also an issue for these users, but it makes little sense to arbitrarily restrict Web page graphics in the cause of "saving bandwidth." The bandwidth nazis and gearheads always miss this point: graphics are what drew most people to the Web in the first place. If you got the access speed, indulge!

The following is a brief overview of color computer displays that explains some of the basic terminology used in the Macintosh and Windows operating systems.

Current color monitors for desktop microcomputers are based on cathode ray tubes (CRT's). Because CRT's transmit light, CRT displays use the red-green-blue (RGB) additive color model. The RGB model is called "additive" because a combination of the three pure colors "adds up" to white light.

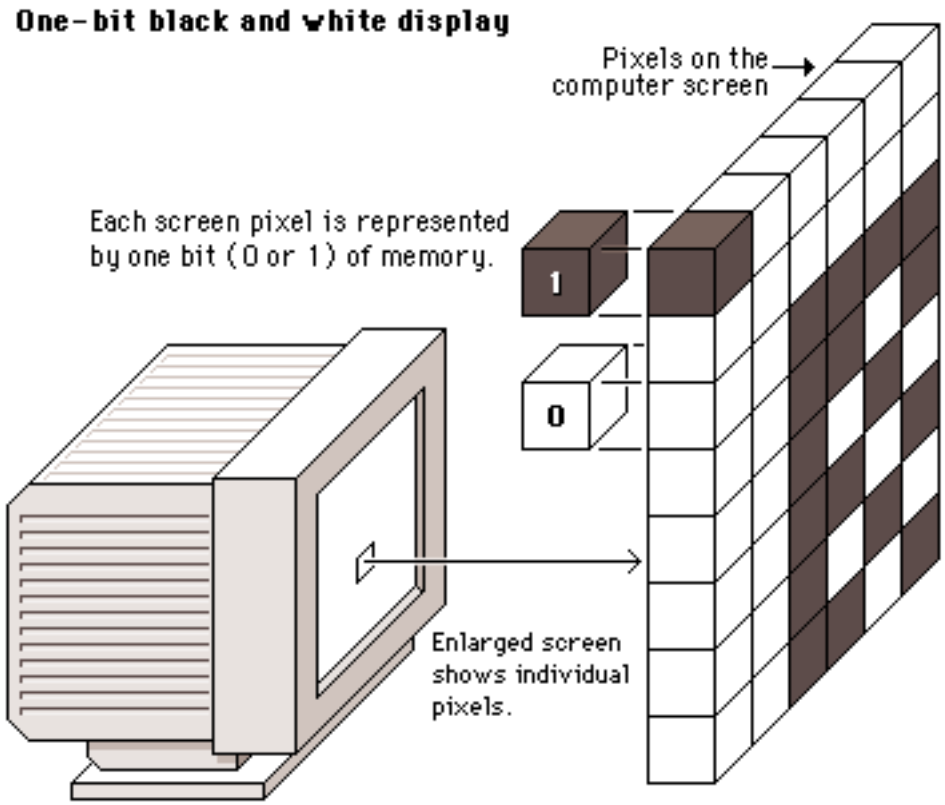
RGB color model for display monitors



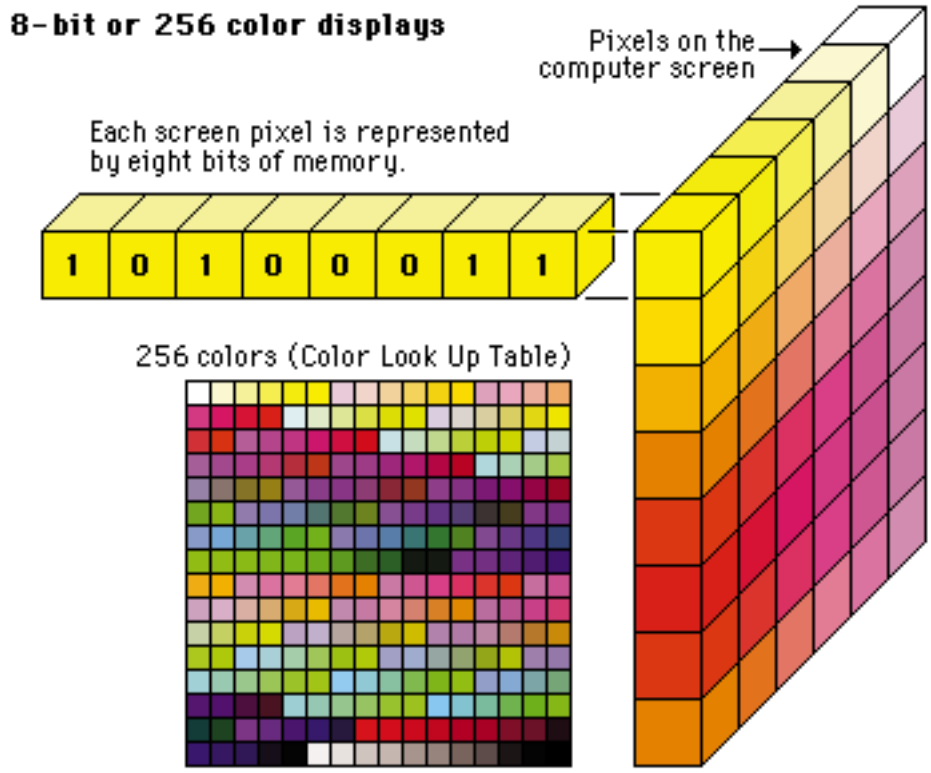
The computer's operating system (Mac, Windows, etc.) organizes the display screen into a grid or x,y coordinates, like a checkerboard. Each little box on the screen is called a "pixel" (short for "picture element"). Current Macintosh and Windows displays are made up of these grids of pixels (see screen diagram below).

Pixels and color

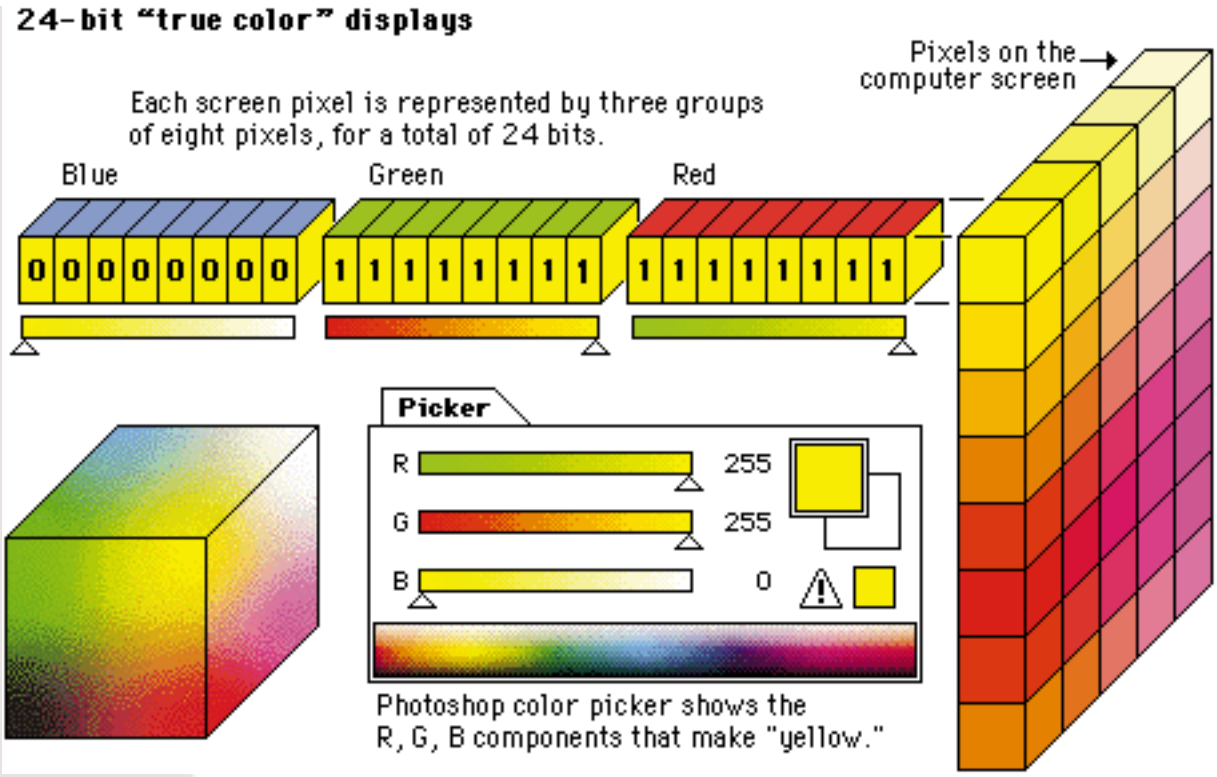
To control the color of each pixel on the screen the operating system must dedicate a small amount of memory to each pixel. In aggregate this memory dedicated to the display screen is often referred to as "video RAM" or "VRAM". In the simplest form of black and white computer displays a single bit of memory is assigned to each pixel. Since each memory bit can only be positive or negative (0 or 1), a one-bit display system can only manage two colors (black or white) for each pixel on the screen:



If we dedicate more bits of memory to each pixel in the display, we can manage more colors. When eight bits of memory are dedicated to each pixel, each pixel could be one of 256 colors. (256 = 2 to the eighth power; in other words, 256 is the maximum number of unique combinations of 0's and 1's you can make with eight bits). This kind of computer display is called an "eight-bit" or 256-color" display, and is very common in current microcomputing, especially on lap-top computers and older desktop machines.

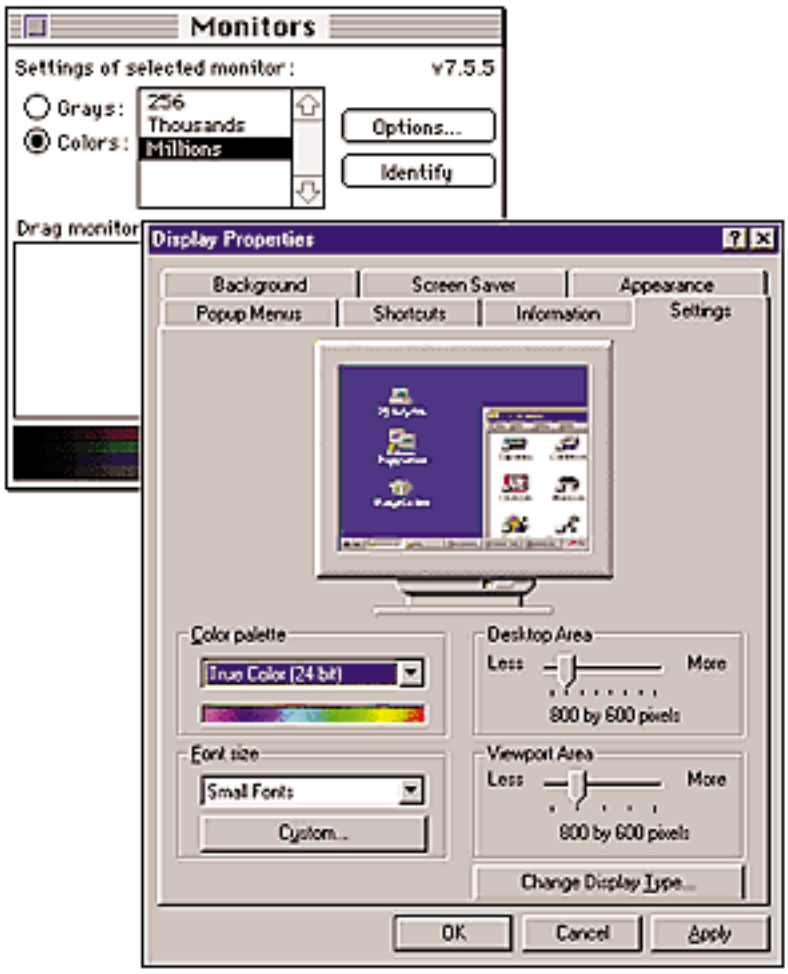


If still more memory is dedicated to each pixel, we can get nearly photographic color on the computer screen. "True-color" or "24-bit" color displays can show millions of unique colors simultaneously on the computer screen. True-color (24-bit) images are composed by dedicating 24 bits of memory to each pixel; eight each for the red, green, and blue components (8+8+8=24).



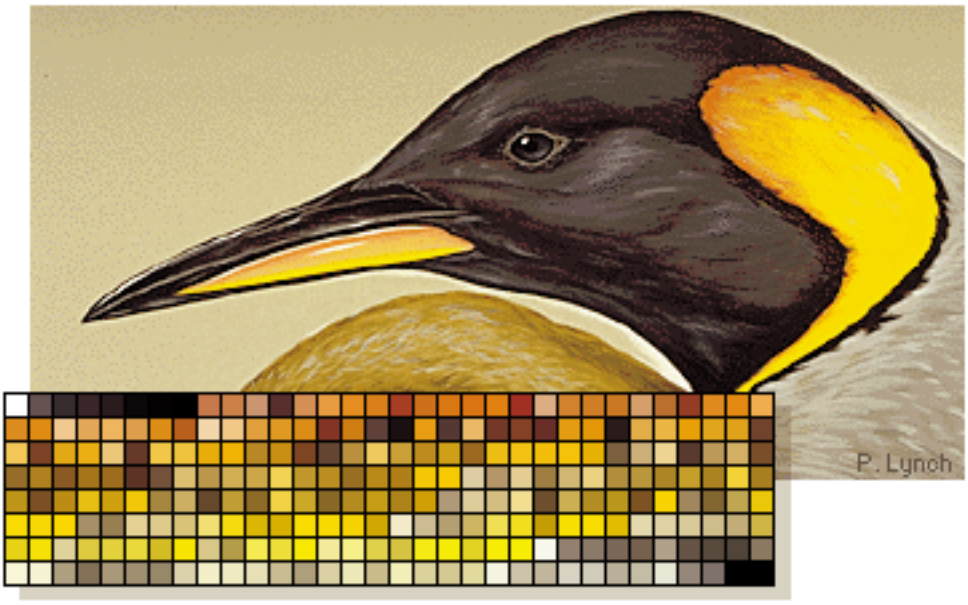
The amount of VRAM dedicated to each screen pixel in the display is commonly referred to as the "bit depth" of the monitor. Most Mac and Windows microcomputers sold in the last few years are capable of displaying bit depths greater than eight-bit, in thousands (16-bit) or millions (24 bit) of simultaneous colors.

To check your computer system for the range of bit depths available to you, use the "Display" control panel (Windows95) or the "Monitors" control panel (for Macintosh):

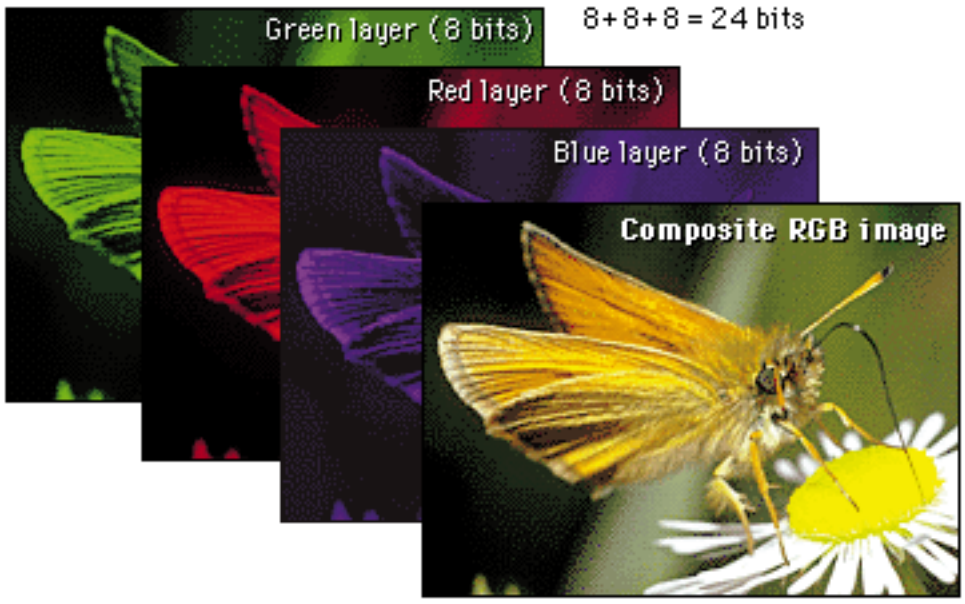


Bit depth and color graphics files

The terminology and memory schemes used in color displays are directly analogous those used to describe color depth in graphics files. In their uncompressed states, eight-bit or 256-color image files dedicate eight bits to each color pixel in the image. In eight-bit images the 256 colors that make up the image are referenced to a "palette" or "index" (also called a color lookup table, or CLUT). The main point for eight-bit images is that they can never contain more than 256 colors.



True-color or 24-bit images are typically much larger than eight-bit images in their uncompressed state, because each pixel in a 24-bit image has 24 bits of memory dedicated to it, typically in three monochrome layers: red, green and blue:



References

Rizzo, J., and K. D. Clark. 1996. *How Macs work.* Emeryville, CA: Ziff Davis Press.

Siegel, D. 1996. *Creating killer web sites.* Indianapolis: Hayden Books.

www.killersites.com

Weinman, L. 1996. *Designing Web graphics.* Indianapolis: New Riders.

www.lynda.com

GIFfiles

The Graphic Interchange Format (GIF) was popularized by the Compuserve Information Service in the 1980s as an efficient means to transmit images across data networks. In the early 1990s the original designers of the World Wide Web adopted the GIF format for its efficiency and widespread familiarity. Today the overwhelming majority of images on the Web are in GIF format. Virtually all Web browsers that support graphics support the GIF file format for inlined images. The GIF format incorporates a compression scheme to keep files sizes at a minimum, and GIF files are limited to 8-bit (256 or fewer colors) color palettes. There are now several slight variants of the basic GIF file format that add support for transparent color, and support for the interlaced GIF graphics popularized by the Netscape Navigator Web browser.

You may see references to the different GIF formats, such as "GIF87a," or "GIF89a." All forms of GIF images will work in Web browsers that support the basic GIF file format, so that you do not have to worry whether your readers will be able to see your GIF graphics, regardless of the GIF version that you use. Users whose browsers support the transparency and interlacing (such as Netscape Navigator and Microsoft Explorer) will see more sophisticated visual effects, but everyone will see your basic GIF images.

GIF File Compression

The GIF file format uses a relatively basic form of file compression (Lempel Zev Welch, or LZW) that squeezes out inefficiencies in the data storage without causing a loss of any data ("lossless compression") or distortion of the image. The LZW compression scheme is most efficient at compressing images with large fields of homogeneous color. It is not very good at squeezing complex pictures with lots of grainy texture. All variations of the GIF graphics file format incorporate LZW file compression. See Siegel (1996) for an excellent discussion on optimizing graphics for GIF compression.

References

Siegel, D. 1996. *Creating killer web sites*. Indianapolis: Hayden Books.

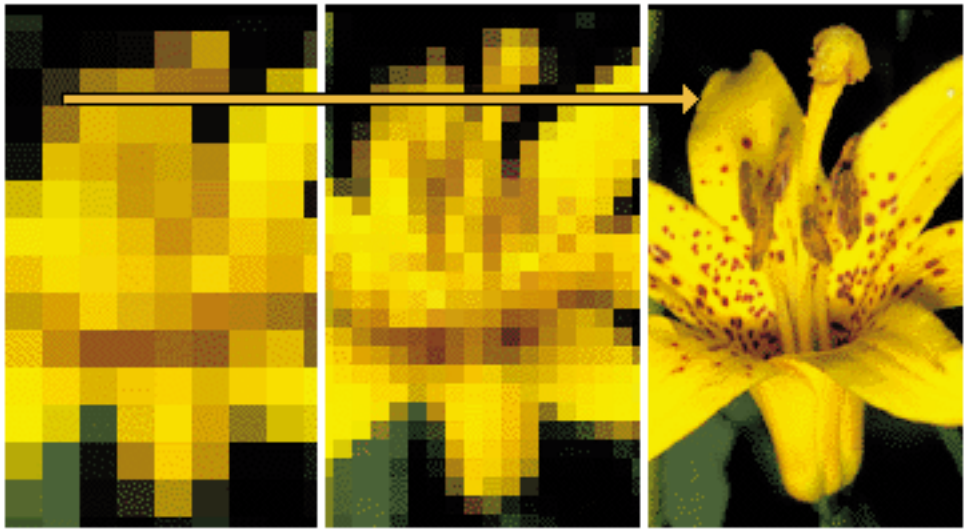
www.killersites.com

Weinman, L. 1996. *Designing Web graphics*. Indianapolis: New Riders.

www.lynda.com

C/AIM

The conventional (non-interlaced) GIF graphic downloads one line of pixels at a time, and Web viewers like Netscape display each line of the image as it gradually builds on the screen. In interlaced GIF files the image data is stored in a format that allows Netscape (and other viewers that support interlaced GIFs) to begin to build a low-resolution version of the full-sized GIF picture on the screen while the file is still downloading. The "fuzzy-to-sharp" animated effect of interlacing is visually appealing, but the most important benefit of interlacing is that it gives the reader a quick preview of the full area of the picture. This preview effect can be misleading interlaced graphics are **not** faster-loading than non-interlaced graphics, they just look as if they download faster because the rough preview comes up faster.



Note that the examples below only work well the **first time** you try them. After that your browser will probably cache the images locally, and subsequent loading will occur (very quickly) from your hard disk, not from the Web. Use your browser's "reload" button to repeat the loading of the graphics if they load too quickly to see the difference. Both example photographs are GIFs, identical except for interlacing.

Example of an interlaced GIF graphic.

Example of a noninterlaced GIF graphic.

References

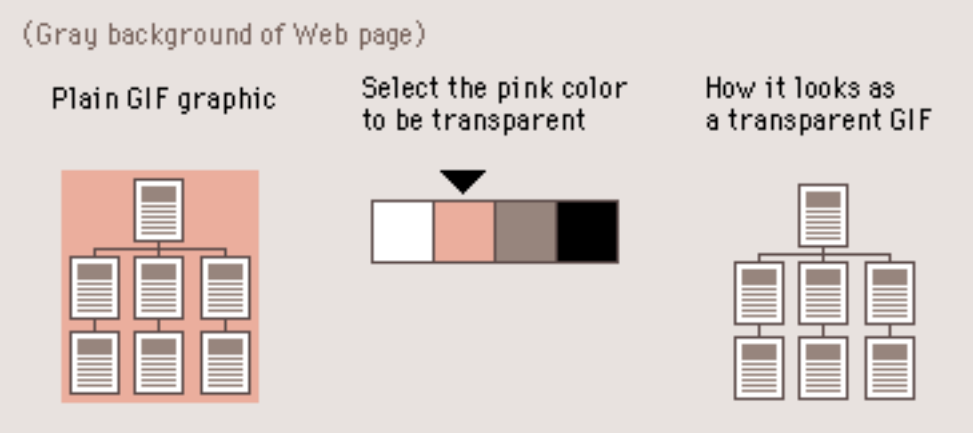
Siegel, D. 1996. *Creating killer web sites*. Indianapolis: Hayden Books.

www.killersites.com

Weinman, L. 1996. *Designing Web graphics*. Indianapolis: New Riders.

www.lynda.com

The GIF89a file format allows you to pick one color from the color lookup table of the GIF to be transparent. Using current image editing software like Adobe Photoshop (and many shareware utility programs) you can select one color to become invisible. Normally the color you select is a background color. In the example below, we chose the pink background color to become transparent:

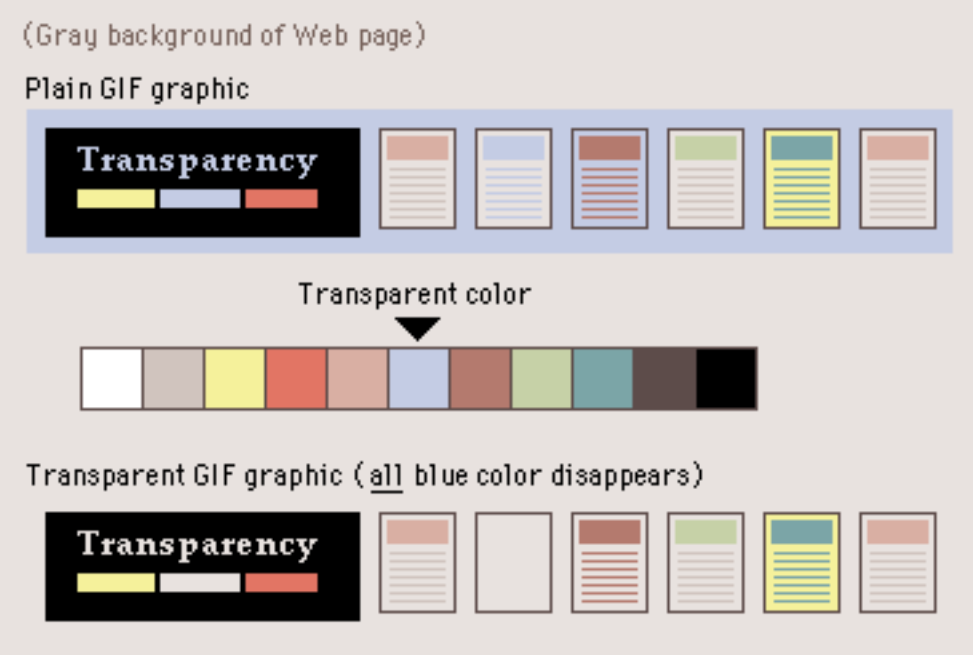


We use transparent GIFs for the header and footer graphics at the top of each page in this manual. The transparent background allows the lettering of the "Yale C/AIM Web Style Guide" to cross over the gray background of the scan column to the white of the page background. The graphic below shows the transparent header graphic on top, and then shows what the same graphic would look like if it was not a transparent GIF:

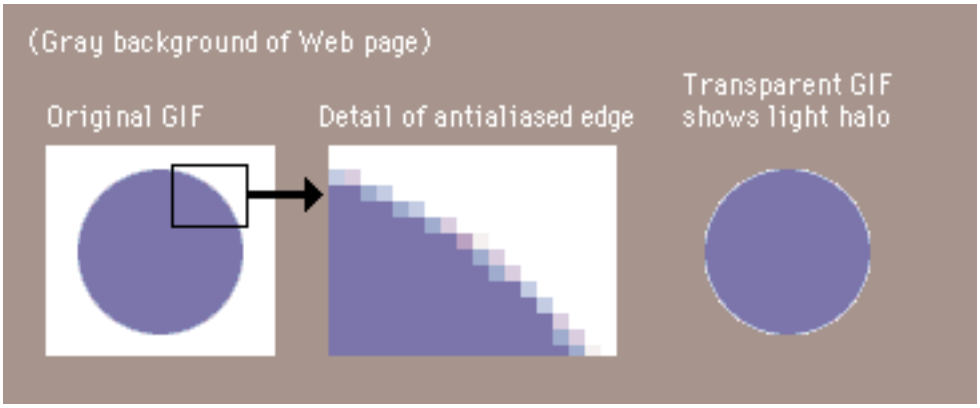
Page header graphic (a transparent GIF)

What the GIF would look like without transparency:

Unfortunately, the transparent property is not selective; if you make a color transparent, then **every pixel** in the graphic that shares that same color will become invisible. This can sometimes have unexpected consequences when a color is used both in the background and in other places in the graphic:



Adding transparency to a GIF graphic can also lead to disappointing results when the graphic contains antialiased edges with pixels of multiple colors. (Antialiasing visually "smooths" the shapes in graphics by inserting pixels of intermediate colors along boundary edges.) In the example below, when we change the background color from white to transparent (letting the gray Web page background show through), we get an ugly white halo around the graphic:



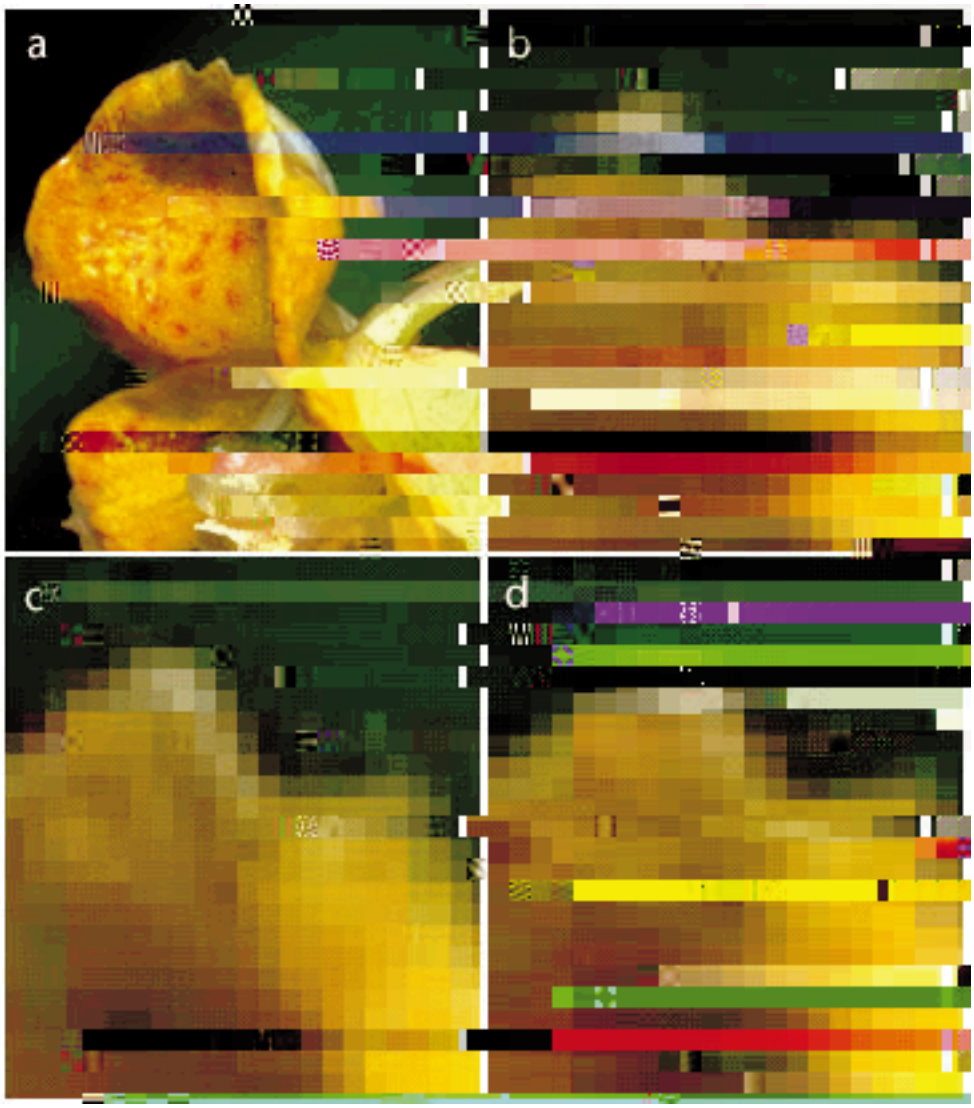
You can avoid some of the problems with antialiased graphics by creating the graphics on a background similar to the color you choose for your Web pages. In our case, we chose white as a background color for the pages in this style guide. The bird painting below is a rectangle (GIF graphics are always rectangles), but you can't see the edges because we painted the background in the GIF white, then set the white color of the GIF to be transparent. This assures us that bird will appear against a perfect

white background every time, and the edges of the graphic will never show:

Transparency works with simple diagrammatic graphics, and with complex shapes. The GIF graphic of the watercolor painting below can run across the scan column and into the white background because we made the white background transparent. We avoided potential problems with a light halo around the leaves in the gray scan column area by retouching the painting to remove the white antialiased "halo" from the leaf edges:

Another graphics file format commonly used on the Web is the Joint Photographic Experts Group (JPEG) compression scheme to minimize graphics file sizes. JPEG images are full-color images (24 bit, or "true color"), unlike GIFs that are limited to a maximum of 256 colors in an image. Thus there is a lot of interest in JPEG images among photographers, artists, graphic designers, medical imaging specialists, art historians, and other groups for whom image quality is paramount, and where color fidelity cannot be compromised.

JPEG uses a very sophisticated mathematical technique called a discrete cosine transformation to produce a sliding scale of graphics compression. Thus you can choose the degree of compression you wish to apply to an image in JPEG format, but in doing so you also are also choosing the image quality. The more you squeeze a picture with JPEG compression, the more you degrade its image quality. JPEG can achieve incredible compression ratios, squeezing graphics down to as much as 100 times smaller than the original file. This is possible because the JPEG algorithm discards "unnecessary" data as it compresses the image, and is thus called a "lossy" image technique. The results are easier to see than to explain. Notice the increasing degradation of the image as we increase the JPEG compression:

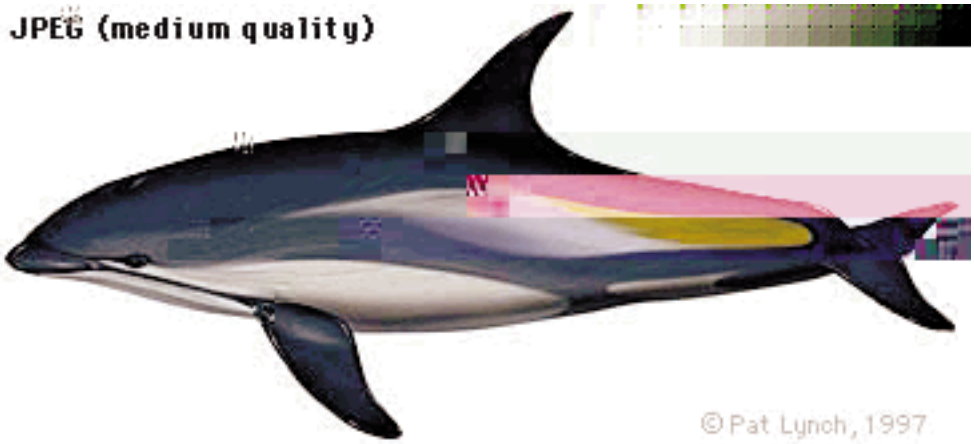


The figure above shows an original photograph (a), and three detail views at different levels of JPEG compression: "excellent" quality (b), "good" quality (c), and "poor" quality (d). Notice the boxy quality of the image in (d). The checkered pattern and the dark "noise" pixels in the green background are classic JPEG compression artifacts.

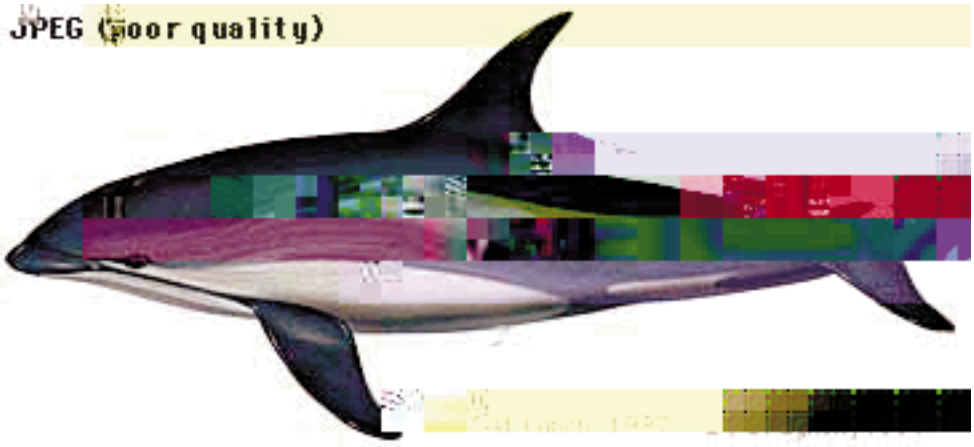
Below is another look at JPEG compression. The top image is an interlaced GIF. The middle is the same image as a JPEG file, compressed in Photoshop at "medium" quality. The bottom dolphin is also a JPEG image, compressed at "poor quality." Note the extensive compression noise and distortion present in the bottom dolphin the savings in download time are not worth the cost of ruining your images.

GIF version

JPEG (medium quality)



JPEG (poor quality)



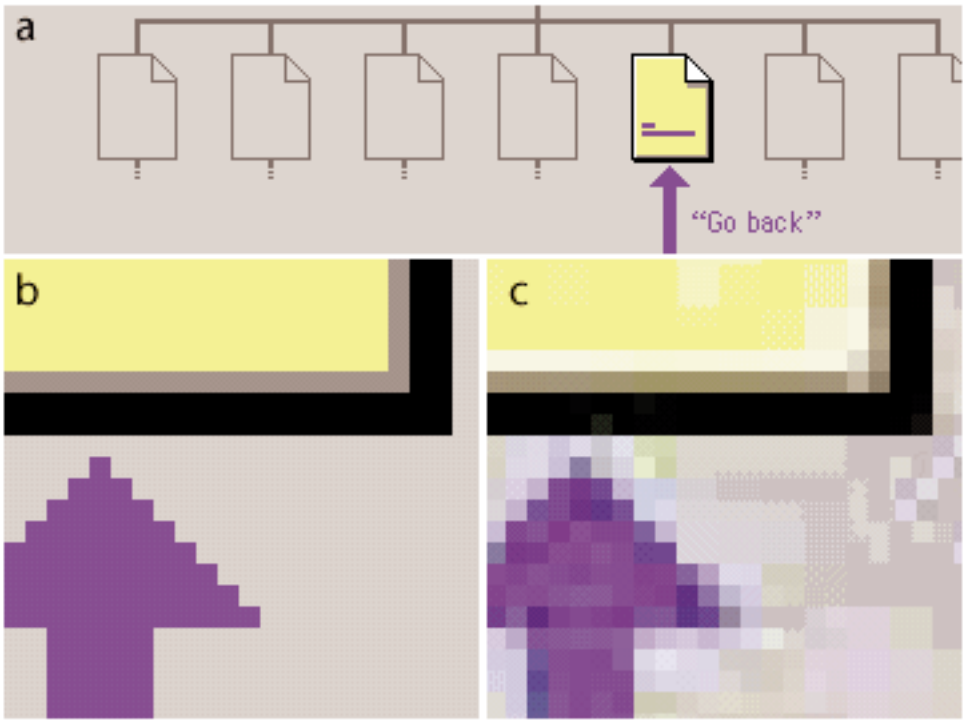
Save your original uncompressed images!
Once you compress an image with JPEG, you have lost data and can never recover it again, so always save an uncompressed original file of your graphics.

A new form of JPEG file called "progressive JPEG" gives JPEG graphics the same gradually-built display seen in interlaced GIFs, but most image editors still do not yet support progressive JPEG files. (Debabilizer 1.6 for the Macintosh is one of the few). Like interlaced GIFs, progressive JPEG images usually take longer to

load into onto the page than standard JPEGs, but do offer a quicker "preview" to the reader.

JPEG Image Artifacts

The JPEG algorithm was optimized for compressing conventional pictorial photographs, and is also very good at handling complex realistic illustrations (which look like photographs). Photos and art with smooth color and tonal transitions, and few areas of harsh contrast or sharp edges are ideal for JPEG compression. However, most page design elements, diagrams, the typography within images, and many illustrations are composed of hard-edged graphics and bright colors that are seldom encountered in photographs (part a; b is a magnification of the diagram). JPEG compression can be quite poor at handling many computer-generated graphics, buttons, type in images, or any other hard-edged "artificial" colored object seen in artwork or diagrams. When compressed with JPEG, diagrammatic images show a "noise" pattern of compression garbage around the transition areas (c, below) the JPEG algorithm "wants" to see smooth tonal transitions and cannot properly reproduce the harsh transitions at the edges of diagrammatic graphics:



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Siegel, D. 1996. *Creating killer web sites*. Indianapolis: Hayden Books.

www.killersites.com

Weinman, L. 1996. *Designing Web graphics*. Indianapolis: New Riders.

www.lynda.com

Uses for GIF and JPEG files

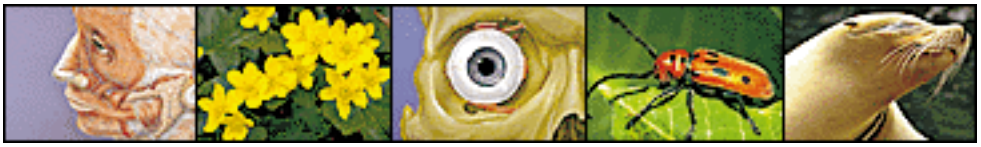
Now that Netscape and other browsers are supporting both GIF and JPEG graphics in inlined Web page images you could use either graphic format for the visual elements of your Web pages. However, in practice most Web developers will continue to favor the GIF format for most page design elements, and choose the JPEG format mostly for photographs, complex "photographic" illustrations, medical images, and other types of images where the compression artifacts of the JPEG process do not severely degrade image quality.

Advantages of GIF Files

The most widely supported graphics format on the Web

- All graphic Web viewers support the GIF format for inlined images.
- GIFs of diagrammatic images look better than JPEGs.
- GIF supports transparency and interlacing.

Advantages of JPEG Images



- Huge compression ratios are possible, for faster download speeds.
- Gives excellent results in most photographs and medical images.
- Supports full-color images (24-bit "true color" images).

The primary challenge in creating illustrations for Web pages is the relatively low resolution of the computer screen. But these days computer screens can also display thousands or millions of colors, and that wealth of color can often make the resolution limitations less noticeable.

Very complex graphics or color photographs often look surprisingly good on Web pages for two major reasons:

- True-color (24-bit) or high-color (16-bit) displays show enough colors to accurately reproduce photographs or complex art.
- The transmitted light from display monitors shows more dynamic range and color intensity than light reflected from printed pages.

Science and education users are just waking up to the fact that digital publishing is inherently color publishing on the Web there is no economic penalty for publishing in color. Web pages may be the best current means to distribute color photography it's a lot cheaper than color printing, and is also more consistent and reliable than all but the most expert (and costly) color printing:

The Web is also great for transmitting complex color artwork to students:

Processing complex illustrations or photographs
The anatomic graphic above was originally painted at much higher resolution in Adobe Photoshop (1000 by 2000 pixels, 24-bit RGB file). We then reduced a copy to the size above, and used the Photoshop "Unsharp Mask" filter (at 60%) to restore the sharpness of the graphic. Although this small version of the painting has lost some resolution and color detail, it still shows all the major anatomic landmarks. We think it is just as good as any equivalent graphic printed in a textbook.

We chose the JPEG file format for the anatomic painting

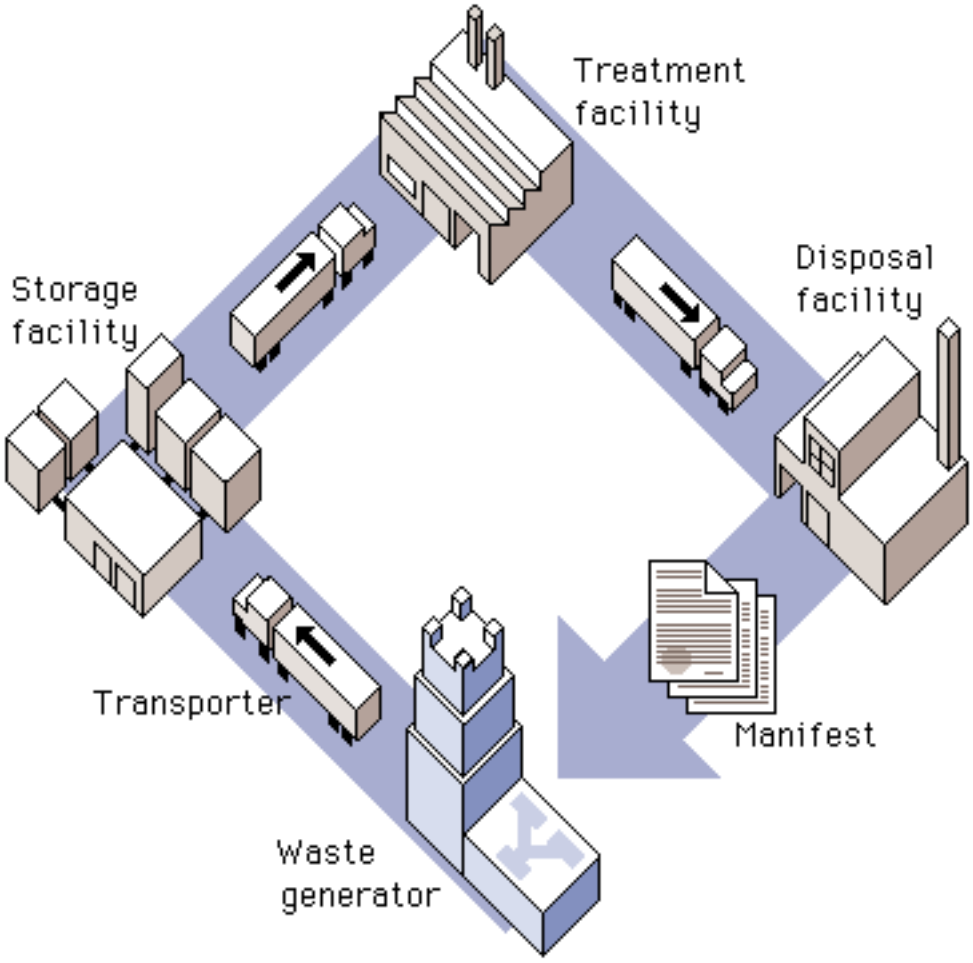
because the artwork is relatively large for a Web graphic. It also does not contain any lettering or diagrammatic elements that reproduce poorly in highly compressed JPEG images. JPEG images can be used for paintings or photographs with labels if you choose the right compression setting. The painting above was compressed in Photoshop at "good" quality," which is the medium setting ("excellent, good, poor"). If you choose the "good" or "excellent" JPEG compression settings text labels may look acceptable, at least on 16-bit or 24-bit displays. Note that the text of the signature is clear and legible, even though close inspection shows there is JPEG noise around the characters. All other graphics on this page are in GIF format, either because they are smaller, or because they contain text or diagram elements.

Diagrams for the computer screen

Basic diagrams also work well on the computer screen if they are carefully designed to match the grid of pixels on the screen. Graphics built with orthogonal lines (straight horizontal or vertical lines) or diagonal lines at 45 degree angles work best for the screen, as this enlarged view illustrates:

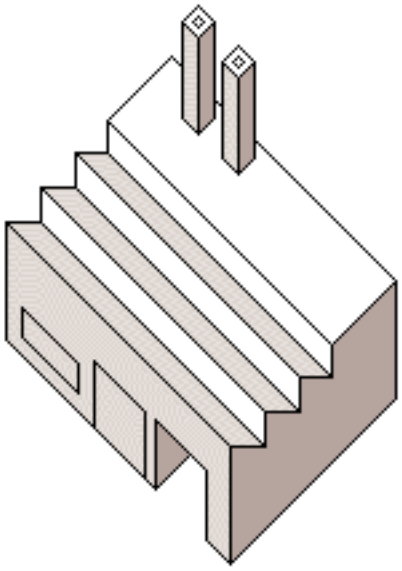
Complex icons are hard to interpret, and look mushy and confusing on the screen. Keep your icons and navigation graphics as simple as possible:

Simple isometric perspective graphics also work well, because they depend on straight lines and 45 degree diagonals.

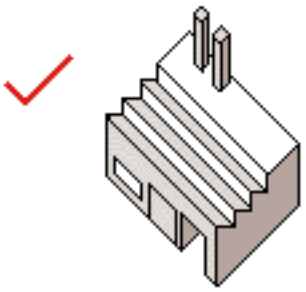


Graphics built carefully to match the pixel grid cannot be resized automatically in Photoshop they must be re-drawn by hand to larger or smaller sizes to avoid a mushy, fuzzy look that destroys their effectiveness:

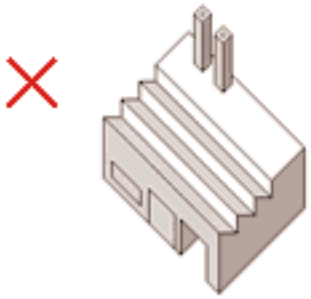
Large graphic



Redrawn graphic



Re-scaled in Photoshop



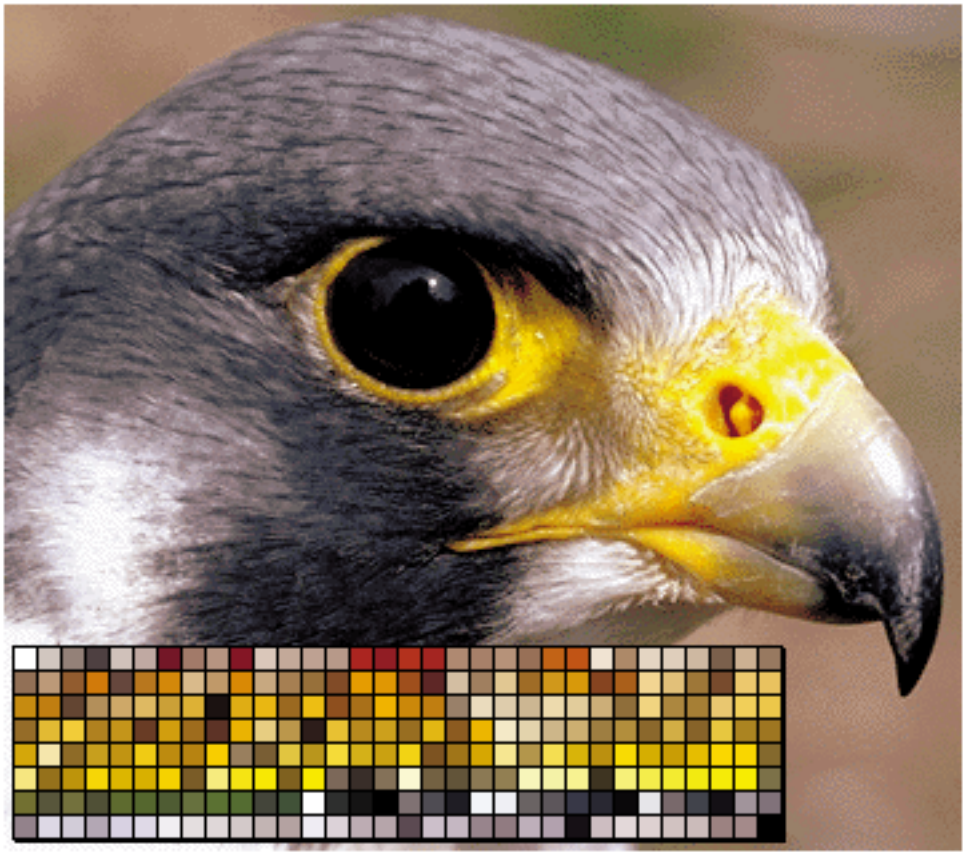
Always use the GIF graphic format for diagrams, navigation graphics, or any graphic that contains text.

C/AIM

Color graphics are one of the defining characteristics of online publishing. Unlike the high cost and complexity of four-color printing on paper, with electronic documents there is no need to economize by avoiding color content. There are some potential performance drawbacks to stuffing your Web pages full of big, bright color images, but with proper planning you can optimize the graphics in your Web pages for faster downloading and more accurate color reproduction on your reader's screens.

Color and GIF graphics

The GIF graphic format was developed to optimize the transmission of image data over networks. To keep file sizes small, the designers of GIF limited the number of colors in a GIF image to 256. Images limited to 256 colors are also referred to as "8-bit images", and may also be called "indexed color" images. "8-bit" refers to the number of memory bits assigned to each pixel in the GIF image. Each digital bit can only be a "1" or a "0," so with eight bits of memory allocated to each pixel there can only be 256 (2 to the eighth power) possible unique combinations of "0's" and "1's." "Indexed color" refers to the 256-color index palette that each image draws its colors from. For example, the GIF image below contains 256 colors, shown on the color palette:



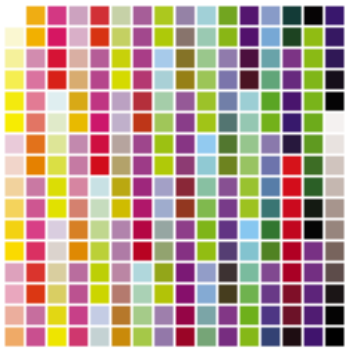
It might seem that 256 colors is more than enough to handle most images, but GIF graphics are quite limited in their ability to handle the almost infinite color range found in most photographs. When you convert a full-color 24-bit image (that typically contain millions of colors) to a 256-color GIF you lose some image detail. Through a process called dithering, image editing programs like Photoshop juxtapose pixels of different colors in a fine dot pattern, to make it seems as if a full range of intermediate colors are present in the image when it is seen at normal viewing distances.

Custom GIF palettes and system palette colors

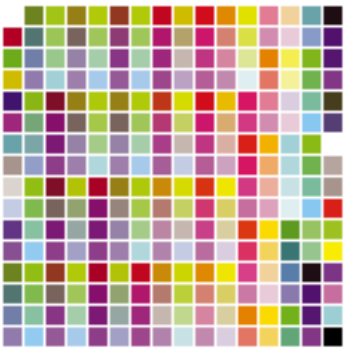
Normally when you convert a full-color image into a GIF you allow the graphics program to choose the 256 colors that best fit that particular image. This results in the optimal GIF image quality, but it does have some drawbacks. The problem shows up when two or more custom-colored GIFs (that could make 512 different colors altogether) need to be on the screen at the same time on a computer display that can only show 256 colors simultaneously (an 8-bit display). **If the viewer of your page only has a monitor that shows 256 colors at one time (like most SVGA and older Macintosh color displays), then the colors in your GIF images will look distorted.**

Most Web viewers like Internet Explorer and Netscape Navigator "solve" the problems of too many picture colors by using the "system palette" of the Macintosh or Windows operating systems. When running on a 256-color screen, the browser forces the range of graphic colors on the Web page to conform to one of the colors in the standard system palette:

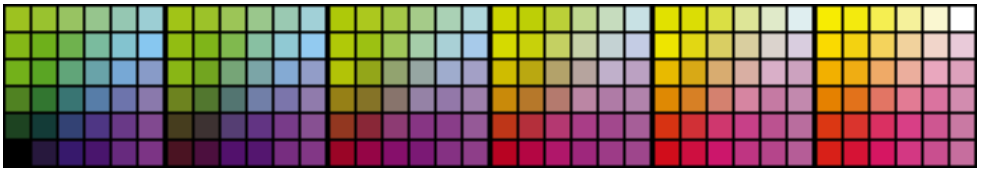
Macintosh system palette



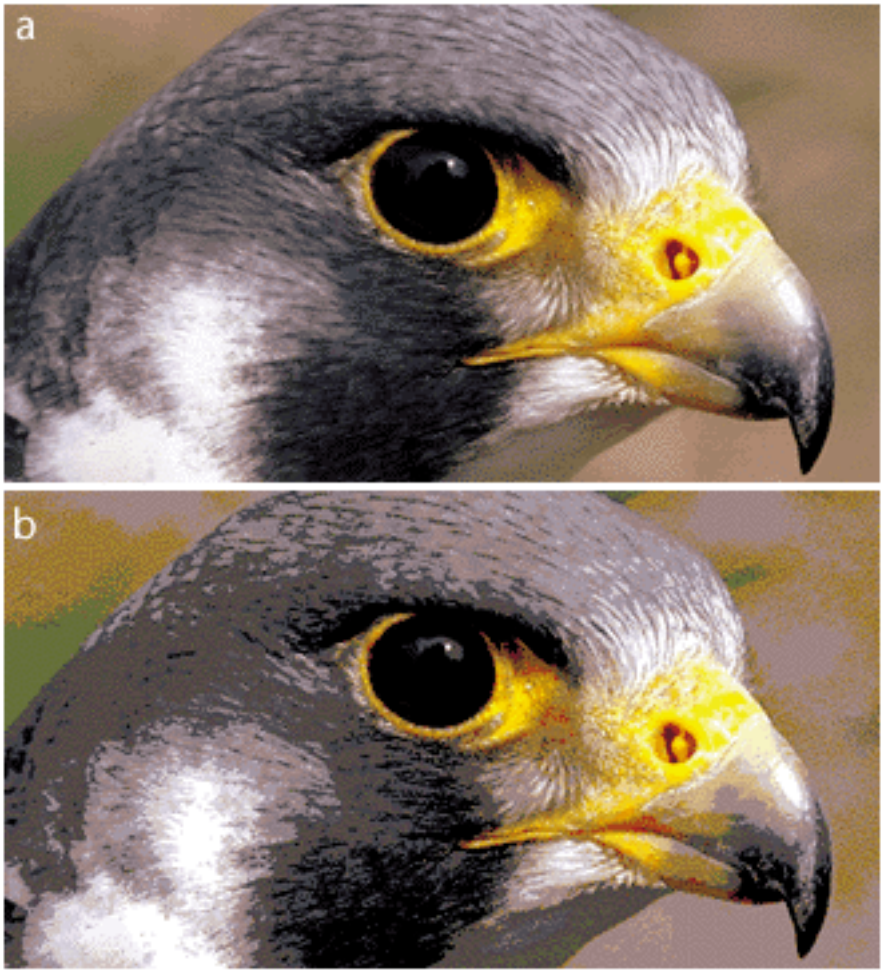
Windows system palette



Unfortunately, the system palettes for the Mac and Windows are not the same only 216 of the colors are identical in both system palettes. A palette incorporating the colors common to both the Mac and Windows is shown below:



Forcing a GIF made from custom palette colors (figure a, below) to display within the limited system palette colors often results in ugly distortions of the image. A Web browser running on an 8-bit display has no way of optimizing your particular custom GIF colors it just uses simple logic to force the picture to display in the nearest equivalent colors in the system palette. The result is often color banding, or harsh distortions of the original colors (b, below):



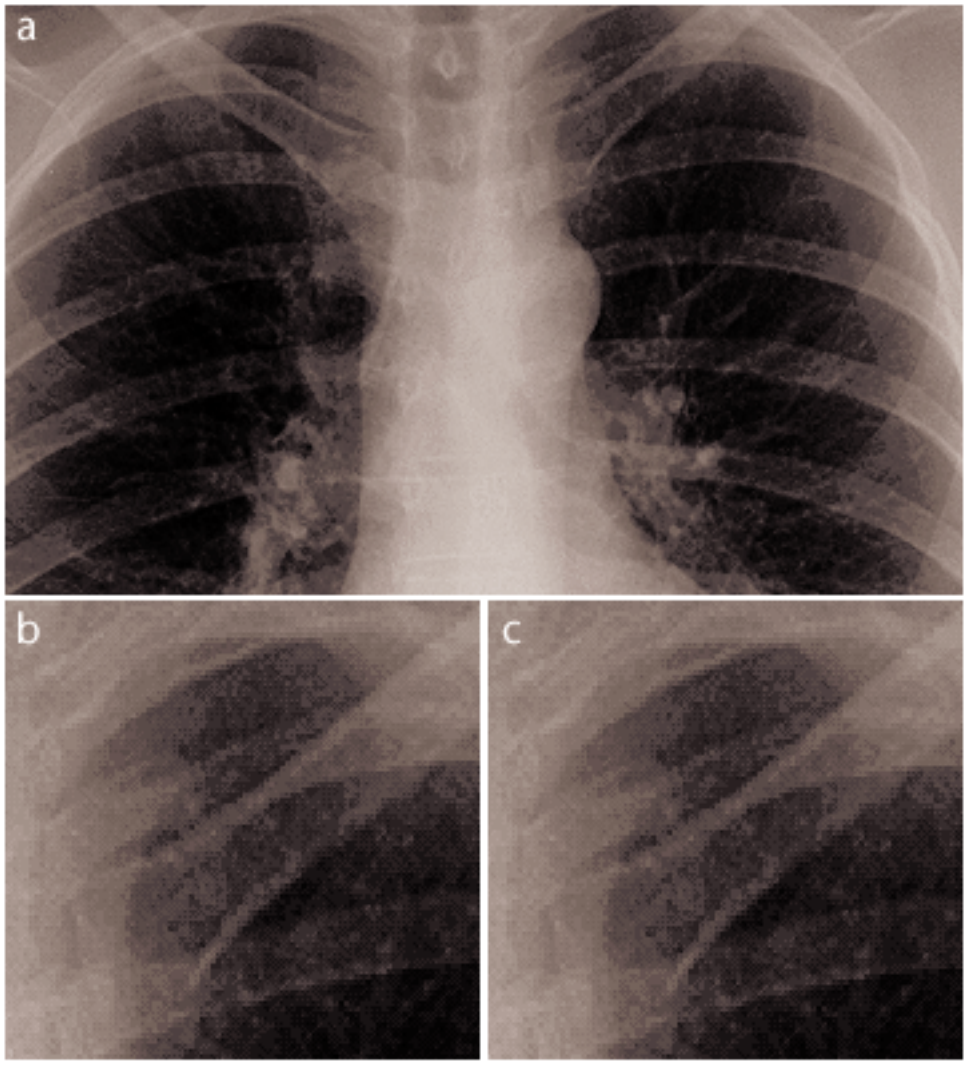
If you use a sophisticated image editing program like Debabilizer 1.6 for the Macintosh you can convert your images to conform to the Macintosh or Windows system palettes, or to a palette that incorporates the colors common to both. You will lose some resolution and color fidelity due to the dithering, but your images should display well on most 256 color displays. the GIF image below has a custom color palette:

This is the same image dithered to the Macintosh system palette. since all RGB system palettes share many common colors, this image will display fairly well on most computer systems. But notice in the detail image how color and image resolution have been lost due by forcing the image into the system palette **you don't just lose colors, you also lose resolution:**

Another option and a better one

You may choose to do what we do most of the time: Use GIF graphics with custom color look-up tables, or JPEG images. Most computer users now work on machines capable of more than 8-bit displays, so many image display problems like unwanted dithering are becoming moot if the user's display is set to a bit depth more than 8 bits they see the original colors of your images. In applications like medical imaging, engineering, and art history (to name a few) image quality is paramount. Use GIF images with custom color look-up tables, or JPEG images, and just accept that some users will see dithered images. You might want to put a small note on your home page advising readers that the images are optimized for 16-bit or 24-bit "true-color" display monitors.

For example, most medical diagnostic images are in black and white. When converted to GIFs with a custom palette of 256 grays and displayed on a 16-bit or 24-bit color display a chest radiograph reproduces without distortion of the gray scale. "B" shows detail from the original uncompressed Photoshop file; "C" shows the same area from the GIF compressed version (e.g., there is no loss of image quality due to compression in GIF graphics):



Always save a copy of your original graphics files and photographs in their full-color state before you make new versions using the system palette. As "high-color" 16-bit and "true color" 24-bit computer displays become more common the issue of color distortion on Web pages will gradually go away, and you may want to replace your 8-bit images with full-color versions a few years from now. But you can only do that if you **saved the originals**.

For photographs or other larger illustrations on your Web pages you might wish to use the JPEG file format. The JPEG format allows more efficient compression of the files, speeding download times on large images. However, JPEG images are inherently full-color images (containing thousands or millions of colors), so JPEG images will also look distorted when viewed on standard 256-color SVGA or older Macintosh monitors. Netscape does a pretty good job of displaying JPEG images on 8-bit monitors, but only a 16-bit or 24-bit display will reproduce JPEG images accurately.

If you put HEIGHT and WIDTH tags into your HTML image source tags, the information tells the browser how much room page space to devote to the graphic. Thus the browser start to lay out your Web page even before the graphics files have begun to download. This does not speed up the downloading of the graphics (nothing but a faster data connection can do that), but it does allow the user to see the basic page layout quickly. When you supply the HEIGHT and WIDTH of page graphics the browser will often fill out the text blocks first, then "pour" the graphics files into the spaces allotted. Thus the user can start to read your page while the graphics are downloading. All of the graphic references in this style manual include height and width tags.

The HEIGHT and WIDTH tags are additions to the basic image source tag:

```
<IMG SRC="picture.gif" HEIGHT="30" WIDTH="475">
```

For best performance, make sure all of your image source tags include height and width information (even for small button graphics).

Note that the examples below only work well the **first time** you try them. After that your browser will probably cache the images locally, and subsequent loading will occur (very quickly) from your hard disk, not from the Web. Both example photographs are interlaced GIFs (300 x 409 pixels).

Load an image **without** HEIGHT and WIDTH tags

Load an equivalent image **with** HEIGHT and WIDTH tags

Web background colors offer a "zero-bandwidth" means to change the look of your pages without adding graphics. They also allow you to increase the legibility of your pages, tune the background color to complement foreground art, and to signal a broad change in context from one part of your site to another.

Background patterns and background images are the most controversial graphic elements on Web pages. Both features add graphic complexity to pages without increasing their legibility. Poor choice of background graphics has generated some of the ugliest pages on the Web. However, in the hands of experienced and knowledgeable graphic designers the use of these background features can result in Web pages as stunning in graphic impact as anything seen in multimedia CD-ROMs.

Changing the colors of page elements

Netscape allows you to specify a specific color for the background, text, and hypertext links of your Web page, making it possible to get rid of the default gray or white background without having to download big graphics. You can also manipulate the colors of other page elements in web pages, using a simple set of HTML extensions. These extensions may be the most efficient way to give you pages a distinctive look, because the browser handles all of the color changes, and your readers do not have to sit still while you download fancy graphics to them.

Picking the background color is easy in WYSIWYG (what you see is what you get) graphic web page layout programs. Unfortunately, picking a color without one of these Web page editors is a procedure only a gearhead could love. The color is specified in the tag in hexadecimal code, where the six elements give the red, green, and blue values that blend to make the color. In the tag, the hex code is always preceded by a "#" sign: (#RRGGBB). Since this whole business is handled visually by the new generation of WYSIWYG page editors, we will not go into further details on the arcana of hexadecimal RGB color selection.

Here are hex color codes for some background colors:

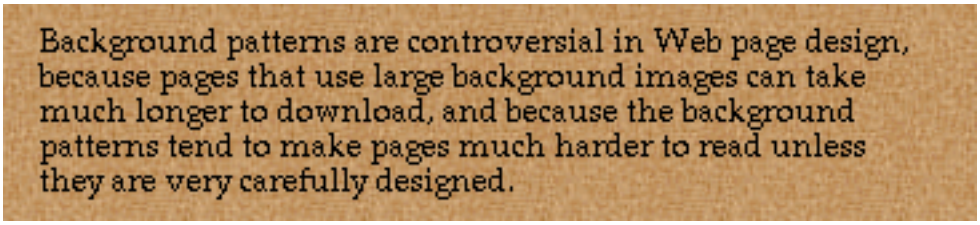
#FFFFFF	#FAFAEC	#E1E5E2	#F0D9C1	#CDC0C0
#DFC3A6	#C2D0E8	#BEE3C2	#B4BCCD	#000000

Using the HTML extensions for changing the color of page backgrounds, text, and link colors is easy you just add a few extensions to the "BODY" tag at the beginning of your HTML code for the page (this particular tag yields a white background):

```
<BODY  BGCOLOR="#FFFFFF">
```

Background colors and legibility
Shifting the page background from gray to white is really the only alteration of the standard Web page background that we can recommend if your highest priority is screen legibility. The legibility of type on the computer screen is already compromised by the low resolution of the computer screen. The typical Macintosh or Windows computer screen displays text at 72 to 80 dots per inch (about 5,200 dots per square inch), or almost 300 time less resolution than a typical magazine page (1,440,000 dots per square inch). Black text on a white (or very light gray) background yields the best overall type contrast and legibility. Studies have shown the black backgrounds are significantly less legible than white backgrounds, even when white type is used (for maximum contrast). Colored backgrounds can work as an alternative to plain Netscape gray if the colors are kept in very muted tones, and low in overall color saturation (pastels, light grays, and light earth tones work best).

Netscape background patterns
Early in 1995 Netscape 1.1N gave Web page authors the ability to use small tiled GIF or JPEG graphics (or a single large graphic) to form a background pattern behind the Web page. The feature is controversial in Web design discussions, because pages that use large background images take much longer to download, and because the background patterns tend to make pages much harder to read unless they are carefully designed:



To be suitable for use as a texture the graphic should be a small GIF or JPEG, ideally no more than about 100 by 100 pixels in size. In our experience, the JPEG background patterns load slightly faster than equivalent GIF graphics. Typical graphics used for background patterns are homogeneous textures:

Background graphics are added to a Web page by Netscape-specific modifications of the standard "BODY" HTML tag:

<BODY BACKGROUND="example.jpeg">

When Netscape sees the BACKGROUND tag it will tile the graphic file "example.jpeg" across the page, under the text and any other graphics. Older Web browsers that do not support background images will just ignore the background tag, and give the page a default white or gray background.

How you might use background textures depends entirely on your goals for your Web site, the access speeds that are typical for your target audience, and whether the multimedia/CD-ROM style look (fast becoming a cliche) meets the aesthetic goals of your Web site. Using large or visually complex background textures on any page that is heavily access by busy people looking for work-related information would be foolish the long download times, unprofessional aesthetics, and poor legibility would instantly create ill will in your users. However, in the hands of skilled graphic designers creating Web pages specifically designed for graphic impact, the option to use background textures opens up many interesting visual design possibilities. This is particularly true in universities and commercial organizations where fast network access is commonplace and bandwidth is not the major issue it is with modem-based users.

Our advice is: if you don't have professional graphic design training or experience in constructing complex graphic communications, then stay away from background images or textures the chances making a bad functional and aesthetic mistake are overwhelming.

Imagemaps offer a means to define multiple "live" link areas within a single graphic on a Web page. Thus you can make a banner graphic for the top of your page, and imbed multiple "button" areas within the graphic. The header and footer graphics used in this style guide are simple imagemaps. This is how the header graphic would look if you could see the "live" areas defined in the imagemap:

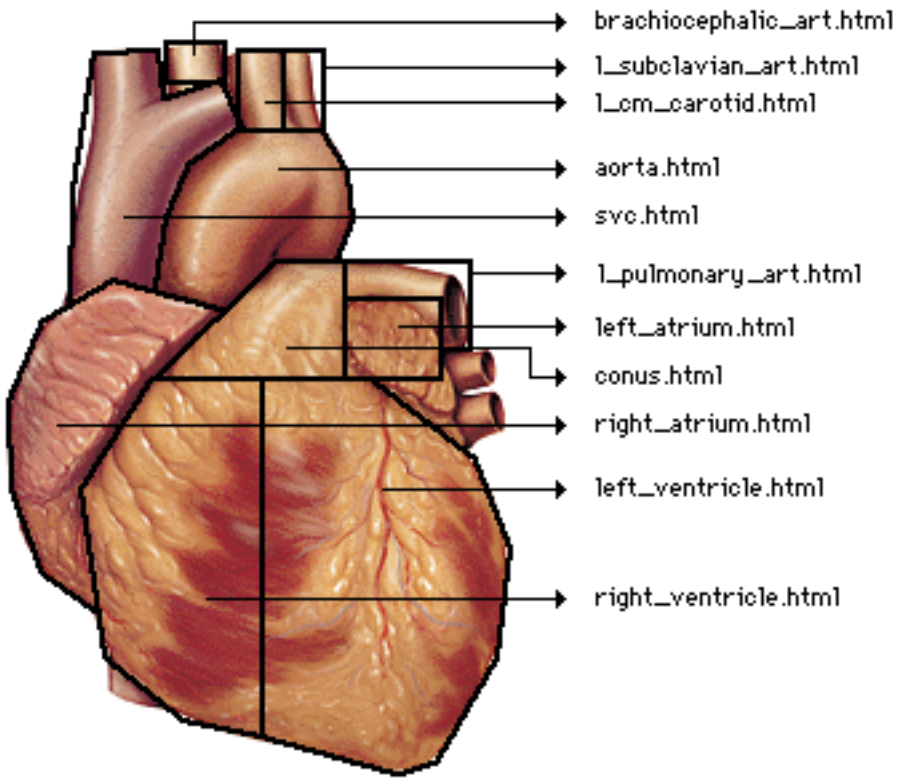
Server-side imagemaps *vs* client-side imagemaps
Until recently Web imagemaps had a reputation for being complex to implement and slow to execute, because the original procedure for creating imagemaps on Web pages required reference to a separate file on the host Web server every time a user clicked on an imagemap. This "server-side" imagemap technology was needlessly complex and very inefficient. Since early 1996 the major Web browsers have supported "client-side" imagemaps, where the information on what areas of a graphic are "live" links is incorporated within the HTML code for the Web page, where it belongs. Most Web page layout programs now incorporate easy graphic interfaces for setting up imagemaps, so we will not cover the HTML technical details here. (See the reference links below for more information on the technical details of creating web imagemaps, or look at the HTML source of any page in this style guide.)

Space-efficient graphic impact
Imagemaps have become a standard feature of most professionally-designed Web sites because they offer an effective combination of visual appeal and, when used properly, space-efficient functionality. Imagemaps are particularly effective when incorporated into moderately-sized "splash" graphics at the top of home pages, or into the "signature" graphics or logos that define your pages. For example, Apple Computer uses an imagemap at the top of their education page that offers 12 different link choices within a distinctive graphic that instantly marks the page as part of Apple's Web site:

Graphic has been reduced from the original size. hed.info.apple.com/

Graphicflexibility

Imagemaps are the only means to incorporate multiple links into a graphic illustration, such as this anatomic example:



Imagemaps are also the ultimate means to overcome the vertical, list-oriented, graphically inflexible norms of conventional Web pages built with standard HTML tags. With imagemaps you can simply abandon HTML page layout, and build links into large graphics, just as you might in CD-ROM authoring programs. This example incorporates very large graphics, and is not suitable for users accessing this guide via modem. In the example the whole page is defined with a JPEG imagemap, placed over another small JPEG used as a background pattern. Designs like these are only suitable for audiences with high bandwidth access to the Web or the local intranet, but this kind of graphic flexibility offers a glimpse at the future of Web page design.

References

Apple Computer, Inc. - Higher Education site

Perhaps the most powerful aspect of the computing technology is the ability to combine text, graphics, sounds, and moving images in meaningful ways. The promise of multimedia has been slow to reach the web because of bandwidth limitations, but each day brings new solutions. The options enumerated here are certainly not the only ones and will surely soon become outdated but they are the solutions we use in our work and have proved to be the most practical and effective for our purposes.

Splash vs. content

Web designers must always be considerate of the consumer. A happy customer will come back, but one who has been made to wait, and is then offered goods that are irrelevant, will very likely shop elsewhere. Since multimedia comes with a high price-tag in terms of bandwidth, it should be used sparingly and judiciously.

Splash screens have become a common location for multimedia elements. Like the cover to a book, splash screens are intended to entice users into a site to open the book and read what's inside. Animations and sound can peak a user's curiosity, compelling them to enter the site and explore. Using "splash" in the interior of a site, however, is not something we advocate. As we discuss in the interface section of this manual, any page element that is not relevant to the content is simply distracting.

The options for content are essentially defined by bandwidth. Audio files can be compressed so effectively that sound can now be considered for site content, particularly for intranet sites. For example, a site about poetry could include recitations; a text about a composer could include excerpts from her work; a language site could include pronunciations.

Animation files at present are not terribly useful as content because of compression limitations. Most animation file formats require the file to be fully downloaded before it can be played, so file size is a serious limitation. And most popular animation formats do not support compression, so if one content-rich GIF image is 30k, two combined makes 60k, and so on.

If your site will be accessed by people using modems, forget about digital video, at least for the moment. The quality compromises required to deliver video to modems altogether obviate its usefulness. However, if your site if intended for use on an intranet, video content is a definite possibility.

Plug-ins

Each day brings a new plug-in that allows users to see new and exciting things using their favorite browser software. This is especially true of multimedia; the options for encoding and

delivering audio, animations, and video are dizzying. It is tempting to create files that utilize the functionality offered by these custom plug-ins, but there are two considerations designers should bear in mind. First, you will loose a large number of users when they hit the "MIME-type not supported, etc..." dialog box.

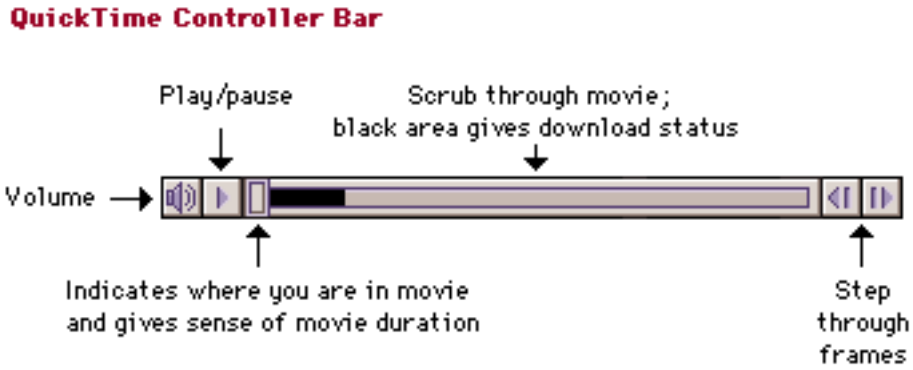
MIME-TYPE DIALOG BOX

The bother and potential confusion of downloading and installing plug-ins will deter a large percentage of users. Secondly, it is not prudent to create content in a custom file format which could quickly become obsolete. It is best to create your multimedia content in the standard formats for operating systems and browser software.

The combination of low bandwidth considerations and primitive interface options create interesting design challenges for web developers who want to incorporate multimedia elements into their sites. There are two main tenets that designers should adhere to: be sure to inform the user that they are entering a high-bandwidth area, and provide them with the tools they need to control their experience once in the area.

Warning! High data rates
Be sure that visitors to your site are informed about the high-bandwidth areas before entering. For example, have the contents page of your site explain clearly where you are sending the user before they decide to go. Also be sure to explain what browser software and plug-ins are required so users are not confronted with unfriendly dialog boxes. And as with all data-intensive site elements, make certain that your multimedia content is relevant. If someone has come to your site to learn more about, say, web style guidelines, and you present them with a video of your pet hamster, you will simply loose your audience.

Keep it friendly
Be sure to provide users with status information and controls when presenting multimedia elements. For example, the QuickTime controller bar, though perhaps not aesthetically inspiring, is an extremely effective interface element that provides both controls and status information. It allows users to adjust the volume of a movie, play and stop and scrub through a movie, and also provides information about the movie's download status.



The problem with dispensing with such elements is that users will hit your page and have no way to control their viewing environment. Say, for example, they are looking at your page at a public computer workstation, and you have looping bird calls as a

page element, but provide no control options. They user has an unsettling moment where they are simply unable to control their interaction with your site.

Qualification

There is one significant qualification in this discussion of multimedia design considerations. If you are creating a site for a specific audience and not for global interests you often have more flexibility and can ask more from your users. You can require them to use specific browser software, plug-ins, and you can take steps to ensure that they know what to expect when visiting your site. We have found this to be true for many of the academic sites we develop. The audience for these sites is usually a group of students or faculty with specialized interests. If we are charged with the task of creating a custom site that fully addresses these interests, function defines form. A site on German poetry for a German grammar class can have bandwidth-intensive audio and video elements because the students who access the site do so for the purpose of using these multimedia elements to enhance their understanding of the poetry. They are not casual visitors; since they are invested in the content, they will tolerate lengthy download times and more demanding site interaction.

QuickTime is the format for video and sound files that we have used in our web projects. It works on both Windows and Macintosh computers without much custom configuration. The latest plug-in for QuickTime is built into Netscape 3.0, so users are not required to do any special installations.

Fast-starting video

The most current versions of the QuickTime plug-in and system software have a feature called fast start. Movies can be saved in a special format that puts all the critical file information at the start of the file data structure. This means that as soon as this information reaches the client machine, the movie can be set to play users do not have to wait until the movie is fully downloaded before clicking on the play button. Depending on network speed, a fast start QuickTime file can be played almost immediately after the page is loaded. If the "autoplay" option is set to true in the movie's HTML tag, the movie will begin playing automatically as soon as the QuickTime plug-in estimates it will be able to play the entire movie without waiting for additional data. As long as the user's connection is faster than the movie's data rate, the movie will play from start to finish without pause.

The implication of fast-start video is that duration is no longer an overriding concern for audio and video site content. At one level, it no longer matters if your video is one minute or 10, because with fast start each of these durations look essentially the same. As long as the user's connection and the movie's data rate are within the same range, your one minute movie can start playing at the same time as your 10 minute movie.

Example of video with fast start

Example of video without fast start

File size is, of course, still a consideration. A 6MB movie file needs to be kept somewhere on the client machine. Some machines will crash if asked to hang onto large movie files. Assess your audience their network access, their processing power and memory configuration and plan accordingly. For example, if you have 10 minutes of video that you want to put on the web for low-end machines, chop it up into smaller chunks to make sure your audience can access it.

Data rate limits

Set the data rate of your movies slightly lower than the throughput of your user's connection is you want them to be able to watch your movies in real time. For a 28.8 modem that means a data rate somewhere around two KBps, for ISDN around five

KBps, and for T1 lines from five to 40 KBps. To deliver true video at these data rates the compromises are great. The image size must be small, the frame rate low, and the sound compressed. As a result of compression the image quality will be less than optimal. Nonetheless, there is still interesting video and sound that can delivered using the web.

Creative solutions
If you are creating content for a web site, tailor your multimedia elements for web delivery. Think of creative solutions that may be more modest but will be viewable by your target audience. For example, instead of using true full-motion digital video and audio that will require so much compression and size reduction as to render it useless, use audio and a sequence of still images to add multimedia to your site. Say, for example, you want to use video to show how to cook lasagna. Instead of using video, take a bunch of still images and pair them with a good-quality narration of the recipe.

Pay attention to source
It is especially important that web multimedia be created from excellent source. The processing that must be applied to A/V elements in order to attain web resolution will only emphasize any flaws in your original source. If you begin with bad audio and then reduce it's sample rate and depth, and then add compression to further reduce the data rate, any flaws present in the original source material will be exaggerated.

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Visual Design for the User Interface
Part 1: Design Fundamentals

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Abstract
Digital audiovisual media and computer-based documents will be the dominant forms of professional communication in both clinical medicine and the biomedical sciences. The design of highly interactive multimedia systems will shortly become a major activity for biocommunications professionals. The problems of human-computer interface design are intimately linked with graphic design for multimedia presentations and on-line document systems. This article outlines the history of graphic interface design, and the theories that have influenced the development of today's major graphic user interfaces.

By the end of this decade digital audiovisual media and computer-based documents will be the dominant forms of professional communication in both clinical medicine and the biomedical sciences. Interactive computer-based instruction is becoming an essential component of medical education, supplementing or replacing many lectures, laboratory experiments and dissections throughout the curriculum. Today most diagnostic imaging techniques and patient case records are already at least partially digital, and by the turn of the century virtually all medical images, patient records, and medical teaching resources will be acquired, transmitted, and stored primarily in digital form. Communications theorists have advocated multimedia "paperless documents" since at least the 1940's (Bush 1945; Engelbart 1963; Nelson 1987), but it was only in the late 1980's that computers powerful enough to store and display such documents became commonplace in hospitals and medical schools. High bandwidth networks of small computers are fast becoming the most influential medium for professional communication in science and medicine, and electronic documents will play an ever-increasing role in the education and clinical practice of medical professionals (Jessup, 1993; Lynch and Jaffe 1990; Shortliffe 1990).

Documents designed for the computer screen may contain and organize many forms of interactive media, including text, numbers, still illustrations or photographs, animations, visualizations of spatial or numeric information, and digital

audiovisual material (see Figure 1). Due to the novelty of these computer-based multimedia (or hypermedia) documents, and to the conceptual difficulties of integrating many forms of media into cohesive presentations, there are no widely recognized standards for organizing electronic documents (Adsit 1992; Lynch and Jaffe 1990). The graphic design and illustration of multimedia electronic documents requires a thorough understanding of the principles and practice of user interface design. As a discipline interface design draws concepts and inspiration from such diverse fields as computer science, audiovisual media, industrial design, cognitive psychology, human-factors and ergonomic research, audiovisual design, and the graphic and editorial design of conventional paper publications. The principles and practice of graphic interface design will influence the professional lives of all biocommunications professionals, as new, highly audiovisual forms of digital communication media augment or replace existing forms of illustration, photography, video production, and print media (Patton 1993).

There are two salient problems in the design of multimedia documents: informing and guiding the computer user through a complex body of information, and the creation of a visual design rhetoric appropriate for interactive computer displays. Both problems are intimately linked with the design of graphic user interfaces for computer systems. The graphic user interface (GUI) of a computer system includes the interaction metaphors, images and concepts used to convey function and meaning on the computer screen, the detailed visual characteristics of every component of the graphic interface, and functional sequence of interactions over time that produce the characteristic "look and feel" of graphic interfaces.

Origins of graphic user interfaces

Computers and computer software operate through largely invisible systems that provide few physical or visual clues to the operational state or organization of the system (Norman 1993). The potential complexity and functional plasticity of computer systems is both their major strength and most obvious weakness-changing the software or operating system can radically change the characteristics and behavior of the computer system. The purpose of graphic user interface design is to provide screen displays that create an operating environment for the user, forming an explicit visual and functional context for the computer user's actions. The graphic interface directs, orchestrates, and focuses the user's experiences, and makes the organizational structure of the computer system or multimedia document visible and accessible to the user.

In the 1960's most truly interactive computer systems were typewriter-like teletype (TTY) terminals that used paper as a

display, printing both the instructions from the computer operator and whatever responses resulted from the computer's activities. Early designers of interactive computer systems using cathode ray tube (CRT) display monitors created graphic and text displays modeled after their familiar single-line-at-a-time TTY paper displays. This teletype metaphor (the "glass teletype") for computer displays is the basis for the MS-DOS operating system's command-line screen display that is still in wide use today. However, even in the 1960's researchers such as Ivan Sutherland (inventor or the first interactive windowing computer display) and Douglas Engelbart (inventor of the computer "mouse") were designing spatial display systems for CRT screens that both emulated the graphic complexity of print documents and used the dynamic character of the computer display to transcend the limitations of graphics printed on paper (Engelbart 1963; Grudin 1990; Sutherland 1980).

Direct manipulation interfaces

During the 1970's the conceptual basis for most current graphic user interfaces was developed at Xerox's Palo Alto Research Center (PARC). These concepts include explicit on-screen graphic metaphors for objects like documents and computer programs, multiple overlapping windows to subdivide activities on the display screen, and direct manipulation of windows, icons and other objects within the interface using Engelbart's desktop mouse as a pointing devise (Smith 1982). Two factors influenced the development of modern graphic interfaces: the direct manipulation of graphic "objects" on the computer screen, and the creation of appropriate interface metaphors-graphic representations designed to encourage and complement the user's understanding of the computer system.

The Xerox PARC work on direct manipulation computer interfaces was grounded in the observations of cognitive and developmental psychologists Jean Piaget and Jerome Bruner (Bruner 1966; Piaget 1954) that our understanding of the world is fundamentally linked to visual stimulation and the tactile experience of manipulating objects in our environment (Kay 1988; Kay 1990). In particular, Bruner's model of human development as a combination of enactive skills (manipulating objects, knowing where you are in space), iconic skills (visually recognizing, comparing, contrasting), and symbolic skills (the ability to understand long sequences of abstract reasoning) lead PARC researchers to try and build interfaces that explicitly addressed all three of these fundamental ways of understanding and manipulating the world around us. Computers (then and now) have always required abstract reasoning; the task of the PARC researchers was to create an interface that would also exploit the user's manipulative and visual skills.

Using the mouse as a pointing devise the PARC team created a on-screen cursor whose movements directly corresponded to mouse movements, and a highly graphic display screen that allowed easy combinations of text and graphics. Working with the PARC computer scientists graphic designer Norman Cox created a set of screen icons (documents, folders, mail boxes, etc.) to make basic components and operations of the computer system visible as concrete objects (Littman 1988). The objective was to create on-screen graphic analogs of familiar real-world objects, to foster the illusion that digital data could be picked up, moved, and manipulated as directly and easy as paper documents on a desktop. Laurel (1991) and many previous observers have noted the similarities between direct manipulation interfaces and Samuel Coleridge's concept of the "willing suspension of disbelief," a term Coleridge coined to describe the audience's intense psychological involvement with representations of reality in theatrical plays. A well-designed graphic interface establishes consistent and predictable behavior for all objects represented in the system, and thus the user suspends disbelief and comes to treat on-screen representations as if they were real, manipulable objects like physical documents, buttons, and tools (Schneiderman 1992). The interface research done at Xerox PARC in the mid-1970's established most of the visual and functional conventions of current graphic user interfaces, and were the direct ancestor of the Apple's Macintosh graphics interface (Apple Computer 1992), Microsoft's Windows (Microsoft Corporation 1992) and the various graphic interfaces that overlie UNIX workstations such as Motif, NextStep, or Open Look (Hayes 1989).

Fundamentals of graphic interface design

Unlike the static graphics of conventional print documents, or the fixed linear sequences of film and video, graphics on the computer screen are interactive, dynamic, and constantly change in their presence or absence on-screen, in spatial position, and in visual or functional character. The visual structure of a graphic user interface consists of standard objects such as buttons, icons, text fields, windows, and pull-down or pop-up screen menus. Through their familiarity, constancy, and their visual characteristics, these interface objects convey very particular messages to the user about the functional possibilities and capabilities of the software in use. This constancy of form and function is a fundamental tenet of graphic user interfaces-the behavior of interface elements should always be consistent and predictable. Graphic interfaces also offer a visual and functional theme or metaphor to the user. Interface metaphors use references to familiar habits, tasks, and concrete objects as a means of making the abstract and invisible functions of the computer easier to understand and remember.

Interface metaphors

After some experience with a complex, abstract system like a computer users begin to construct a conceptual model or "user illusion" (Kay 1990) of the system as they imagine it to be organized. This mental model allows the user to predict the behavior of the system without having to memorize many abstract, arbitrary rules (Norman 1988). The primary goal of interface design is to create and support an appropriate and coherent mental model of the operations and organization of the computer system. Graphic user interfaces incorporate visual and functional metaphors drawn from the world of everyday experience to help orient the computer user to the possibilities and functions of the computer system. By emulating the look and behavior of familiar, concrete screen objects such as file folders, paper documents, tools, or trash cans the functions of the computer system are made visible and placed into a logical, predictable context.

One of the most familiar and widely imitated metaphors is the "desktop" interface created at Xerox PARC in the 1970's for the Alto and Star computers. The designers at PARC reasoned that since those small computers would be used in an office environment an on-screen emulation of everyday office objects would make the computers easier to understand. The Alto and Star systems were the first computers to employ graphic icons representing commonplace office objects to represent documents, file folders, trash cans, mail boxes, and "in" and "out" boxes to represent other office fixtures. Interface metaphors facilitate what Norman (1993) calls experiential or reactive cognition, where you gain information about the functionality of the computer as you interact with various objects in the interface. You don't memorize commands-you react to a rich set of information presented by the graphic interface. Various interface elements both tell the user what actions are possible-the items listed on a pull-down menu, for example. The proper function of objects ought to be self-exemplifying through metaphor: to throw things away, put them in a "trash can", to store things, put them in a folder. But simply adding graphics and a mouse to the user interface does not automatically make a system easy to use or understand. As computer system mature and add capabilities many computer users now (justly) complain about the functional and visual complexity of current graphic user interfaces. Although graphic interface metaphors are widely accepted they are often poorly executed, resulting in software that is difficult to understand and use. Difficulties in the design of graphic interfaces most often arise because from two problems: inconsistent or confusing relationships between interface objects, and poor visual design of the computer screen.

Successful interface metaphors should be simple systems that do not require the user to learn and remember many rules and procedures. If the user is forced to remember many arbitrary rules the primary value of the metaphor is lost, because the "rules" governing the user's interactions ought to be self-evident in the metaphor. For example, after placing a document icon inside a folder you ought to be able to then open the folder and see the document inside. You naturally assume that the document will stay inside the folder until you move it, and that you could put one folder inside another just as you can with real physical folders. If any of these assumptions were not consistently supported throughout the user interface the whole concept of folders as an organizational metaphor would be pointless. Most document metaphors are based on book or paper models because most people are familiar with the basic organization of books, but designers of electronic documents often neglect to fully support the print metaphor with page numbers, chapters, contents displays, or an index. Figure 1 shows the design of medical teaching application that uses a print-like screen metaphor, with paging buttons and page numbers at the bottom right of the screen. Successful interface metaphors draw heavily on the user's knowledge of the world around them, and on established conventions that allow the user to predict the results of their actions in advance (Norman, 1988).

In well-designed, well-documented user interface systems such as the Apple Macintosh or Microsoft Windows graphic interfaces the proper functional and visual design of all standard interface metaphors and other elements is thoroughly described (Apple Computer 1992; Microsoft 1992). Although the graphic design and illustration of computer documents may involve many issues not explicitly addressed in standard interface guidelines the visual designer of computer documents should nevertheless be thoroughly familiar with the functional standards of the particular graphic user interface system in use. Unfortunately there is no digital equivalent of the Chicago Manual of Style (1982) for the design of multimedia computer documents. Most current graphic interface standards were written with tool-oriented software in mind, and are only now beginning to incorporate guidelines for the integration of text, graphics, hypermedia links (see Lynch and Jaffe, 1990), and audiovisual media within computer software documents. In the absence of widely agreed-upon editorial standards for computer documents visual designers must proceed carefully to avoid creating systems that are more confusing than helpful to the computer user. The graphic interface standards set by Apple and Microsoft offer some of the few consistent stylistic and functional guidelines available to computer document designers.

Modality

Software modes exist to provide special (usually temporary) interpretations or contexts for the actions of the user. Poorly designed modal behavior can confuse users and artificially limit their freedom of action. For example, early word processing programs required the user to enter a "Copy Mode" before selecting and copying blocks of text. Once the user enters copy mode no other text editing actions were possible until the user left the copy mode. Although all complex software inevitably incorporates some modal behavior early personal computer software was often highly modal, and therefore was often difficult to learn to use. In the late 1970's and early 1980's most personal computer software interactions followed a "verb-noun" model of user interface design that relied heavily on modal states. Verb-noun models of interaction relied on modes primarily to limit the user's range of action, because by artificially restricting the user's range of choices the software was much easier to program. To paste a piece of text you had to enter "paste mode" (the verb), then select the text (the noun) to be pasted. This style of interacting with computers is often confusing because it is very easy for users to forget which mode they are in, and it is difficult to remember the commands to get into and out of all the modes within a complex program (Schneiderman 1992). Current graphic interfaces like Windows or the Macintosh operating system follow a generally modeless noun-verb model of user interaction. For example, to copy a piece of text you point and select the text (the noun), then copy the text (verb) to the new location. No special modes restrict the user's actions.

However, not all software modes are detrimental or confusing. Most graphics software incorporates mild forms of modal behavior in drawing and painting tools. When a "paint brush" is selected the cursor typically changes to a unique brush cursor, and from then all of the users actions are interpreted as painting-related until another tool is selected. As long as the mode makes sense to the user (painting with a brush-like cursor in a graphics program) and the shift in context is clearly signaled (by changing the cursor, or highlighting a tool in a tool palette), then well-designed modes may actually make the software easier to understand and use (Apple Computer 1992). In general the use of restrictive modal behavior should be avoided in electronic documents unless there is a logical, highly functional purpose to restricting the user's freedom of action.

Locus of control

The user should always feel in direct control of the computer interface, and should never feel that the computer has "automatically" taken actions that could arbitrarily change the user's preferences, destroy data, or force the user to waste time.

Well designed interfaces are also forgiving of user's mistakes, and are stable enough to recover "gracefully" if the user makes mistakes, supplies inappropriate data, or attempts to take an action that might result in irreversible loss of data. For example, it is very easy for programmers to change basic system variables like screen colors, the colors of standard interface objects, sound volume settings, or other visual and functional aspects of the interface normally controlled by the user through "Control Panels" or "Preferences" features of the operating system. These actions are strongly discouraged by the Macintosh and Windows interface guidelines, because these fundamental choices about the set-up of the computer should always be left exclusively to the computer user. (By analogy, imagine what it might be like if advertisers could control the volume level or brightness of your television set during commercials.) Abrupt changes in the perceived stability and constancy of the interface are confusing to the user and rapidly lead to a lack of confidence in the design integrity and reliability of the computer system. For similar reasons the interface guidelines for most graphic interfaces strongly discourage programmers from attaching any consequences to moving the cursor around the computer screen (Apple Computer 1992; Microsoft Corporation 1992). Users correctly assume that they are free to move the cursor around the screen, and that only after explicit action is taken (by pressing the mouse button and clicking on a screen control object like a button or window) will there be any action taken by the computer.

Feedback and time in the interface

Proper management of time is essential in user interfaces. Computer users engage in a complex dialog of event and response, action and reaction with the operating system and user interface of their computers. Interface feedback is the process of managing the timeliness and manner of the computer's response to a user's actions. Feedback from the user interface should be immediate and unambiguous, in the form of visual or auditory signals that the computer has received input from the user and is acting upon that stimulus. Even small gaps in time (0.25-0.50 seconds) between the user's actions and any reaction from the computer can confuse the relationship between cause and effect, or force the user to assume that the computer or software has misinterpreted the user's actions (Horton 1990; Marcus, 1992). Visual signals that provide feedback from the interface are fundamental design features that are often overlooked until they are poorly executed or absent. In most graphic interfaces clicking on a screen button momentarily causes the button colors to reverse (white buttons turn black for a second) as an explicit signal that the button was "pressed" or clicked on. Since tactile cues are absent in these "virtual" screen buttons explicit visual or

audible cues (playing a button "click" sound, for example) are necessary to give users confidence that their actions are "understood" by the computer and are being processed.

Our expectations about the "normal" speed of events is determined by the world around us, not by the slower and sensory-poor environment depicted on the computer screen. It doesn't take much computer experience to realize that personal computers process information too slowly to mimic the speed at which most "real world" events occur. This technological limitation will disappear within a few years as silicon-based "reality engines" bring high speed, fully shaded animations and high-quality video to the personal computer. However, at today's more modest computing speeds interface designers must carefully manage processing delays in the user interface, and provide users with feedback the proper visual , text, and other on-screen cues about the state of the computer's operations at any give moment. In addition to the immediate visual feedback after the user clicks on a button (confirming that some process has been initiated), the interface should always give the user a visual signal to wait while the system processes information even if the delay is only a second or two. Any delay longer than a few seconds without any indication of normal processing activity (such as the Macintosh "watch" cursor, or the Windows "hourglass" cursor) is likely to be interpreted as at least or troubling ambiguous behavior. Long delays without feedback are likely to be seen as system or program errors (Apple Computer 1992; Microsoft Corporation 1992).

Computers excel at storing and retrieving information, but in one important sense most personal computers have very little memory. Although today's computer interfaces may often be a bit slow at providing information the instant the user requests it, by design today's graphic interfaces are largely trapped in the immediate moment and provide little evidence of the history of a user's interactions with the computer. For example, even the most advanced graphic user interfaces usually support only one level of the "undo" command; the system only remembers the user's last action and has no other record of the user's previous interactions with the system. This lack of memory is particularly unfortunate in multimedia teaching or testing systems, where the user could often benefit from a detailed record of past actions, lists of screens that were visited, or a record of the sequence of actions that lead to a particular result. Multiple levels of "undo" could also prevent mistakes and data loss where the user did not realize there was a problem until many further steps had been taken and no single-step "undo" was possible. Some applications have started to implement "historical" features that record as least some aspect of the user's interactions with the program over time. HyperCard's "Recent" screen (see Figure 2) gives the user a

chronological listing of the last 42 screens (or "cards") visited during the current session (Apple 1991). Users can quickly scan a graphic review of their HyperCard session, and "back up" to a previous screen by clicking the image of the screen. As system software becomes more sophisticated software "agents" can be designed that can learn and remember the user's action over longer periods of time, and process this information to help predict the user's needs, or provide a detailed "audit trail" over an extended period of time so that almost any action could be identified and reversed if necessary.

Organizing information

Most of our modern concepts about structuring information stem from the organization of printed books and periodicals, and the library indexing and catalog systems that grew up around printed information. The "interface standards" of books in the English-speaking world are well established and widely agreed-upon, and highly detailed instructions for creating books may be found in guides like The Chicago Manual of Style (1982). Every feature of a book, from the table of contents to the index and footnotes has evolved over the centuries, and readers of early books faced some of the same organizational problems facing the users of hypermedia documents today. Gutenberg's bible of 1456 is often cited as the first modern book, yet even after the explosive growth of publishing that followed Gutenberg it took more than 100 years for page numbering, indexes, tables of contents and even title pages to become routine features of books. Multimedia and hypermedia documents must undergo a similar evolution and standardization of the way information is organized and made available in electronic form.

Highly audiovisual and interactive computers have lead designers to propose novel spatial and conceptual metaphors in data organization and storage, and many digital information theorists have explicitly rejected print standards as an organizing metaphor in electronic documents in favor of hypertext metaphors (Landow 1989; Nelson 1987). Unfortunately many readers find the hypertext or hypermedia disorienting and difficult to navigate through, and lately the interest in complex hypertext systems has cooled as designers struggle with the task of creating systems that incorporate the unique capabilities of computers without disorienting the reader (Gygi 1990; Norman 1990). There seem to be no widely agreed-upon spatial topologies or other organizing principles for an multi-dimensional electronic information space (Conklin 1987; Norman 1993), and it is proving to be very difficult to give the reader of free-form electronic information databases an understandable conceptual model that represents a complex, interconnected web of both existing and potential links between units of information.

The most practical current solutions to the organization of electronic documents build upon widely established print metaphors while gradually incorporating search, retrieval, and associative linking functions that are only possible in computer documents. Graphic maps (Figure 3) that give an overview of information structure are make it easier for users to establish a sense of location within the organization of electronic documents (Ambron and Hooper 1988; 1990). Figure 3 artwork courtesy of Anne Altemus, National Library of Medicine. Standard elements of graphic interfaces such as pull-down menus (see Figure 4) can form a highly interactive "table of contents" that both gives the reader a constant reference to the information topics available, and using menu checkmarks or other signals to mark the current location also gives the reader a sense position within the document (Lynch, et al. 1992). Building a conceptual model that tells the user what is possible within the document, and makes explicit the organizational structure of the document.

Summary

The world-wide digital communications networks that are now being built will dramatically improve the availability and flexibility with which medical and scientific information may be stored, transmitted, and retrieved, but the benefits and opportunities offered by the new digital media will only be fully available to those biocommunications professionals able to create publications and audiovisual systems specifically designed for highly interactive digital media.

In spite of all of the obvious power, efficiency, and flexibility of digital media, it is a curiously disembodied form of communication. Unlike older media such as print or even videotape, digital information has no required physical form, and one of digital media's main advantages is precisely that it can change form and arrangement in response to the user's interactions. The homogenous, highly abstract, and largely invisible form of digital media requires an interface to give form and accessibility to information. Human interface design, as applied to the design of interactive digital audiovisual systems and electronic documents, will shortly become the dominant activity of many biocommunications professionals.

Digital display screens pose unique challenges to graphic designers and medical illustrators. The second part of this paper concerns the visual design of digital multimedia systems.

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Visual design I
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Evolving multimedia

Visual Design for the User Interface
Part 2: Graphics In the Interface

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Abstract
Highly interactive multimedia electronic documents pose unique graphic information design problems. This paper is a discussion of some of the graphic design considerations that are unique to electronic documents. This article discusses the challenges of adapting existing graphic design skills to electronic documents that are displayed and read from computer screens.

Sophisticated graphic information design skills are crucial in the creation of both computer software (tool-oriented software) and in the design of electronic documents (content-oriented software). Visual design skills affect virtually every aspect of software interface design, from the graphic details of the more generic interface objects like windows to the animated illustration of interactive three-dimensional structures within electronic documents (Marcus 1992; Schneiderman 1992; Tognazzini 1992; Tufte 1989). The following is a discussion of some of the factors that designers must consider when creating illustration and visual designs for graphic interfaces and multimedia electronic documents that will be used or read from computer screens.

Characteristics of computer displays

Graphics, text, and numbers printed on paper have been the dominant communications media in Western civilization for at least the last 500 years, and graphic design schemes for computer displays emulate many aspects of the style and organizational conventions of paper documents. However, computer displays in common use today share characteristics that make them very different from paper pages, and these differences pose new challenges to the illustrator and graphic designer.

The first factors to consider are the shape and spatial resolution of computer screens. By convention most paper publications are oriented vertically, while most computer screens are horizontal rectangles. The small size and relatively low resolution of conventional office computer screens has lead most interface designers to avoid directly emulating vertical page layout grids used in paper documents. Most viewers expect to see the whole "page" on the screen at once. A vertical layout larger than the screen size requires the reader to constantly scroll

around within a window without ever getting to see the whole "page." This is confusing, because it forces the reader to constantly remember objects that are not always visible on the screen, turning what should be an easy reading experience into a much more difficult task of remembering the nature and location of unseen information (Horton 1990; Norman 1993).

The relatively low spatial resolution of computer screens and the small size of most computer displays combine to limit the complexity of screen graphics. Most current office display screens offer resolutions of 640 by 480 pixels (72 pixels per inch), or about 5,184 pixels per square inch of screen. Line artwork and typography in magazines printed on coated paper typically have resolutions of at least 1,440,000 dots per square inch (1200 dpi), or about 278 times the resolution of a typical computer screen. Using the technique of graphic antialiasing (see Figure 1) the apparent resolution of type and graphics may be increased on the computer screen. Reading tests have consistently shown that low-resolution text on the computer screen is less legible than high-resolution text on the printed page (Wright 1983). When reading antialiased text readers scores could be brought up to almost 98 percent of scores from paper documents (Brand 1987; Schmandt, 1987), but unfortunately system-level support for antialiased text is not routinely available yet in personal computers. However, designers should take very opportunity to render antialiased images as a means of increasing the legibility of the screen. For example, most complex illustrations, large type, and background graphics in multimedia programs are bitmap ("paint") graphics. Display type and illustrations rendered in PostScript illustrations programs like Adobe Illustrator (Adobe 1993d) or Aldus FreeHand (Aldus 1993) may be imported and converted to antialiased bitmap graphics with image edited programs such as Adobe Photoshop (Adobe 1993). This allows the same PostScript illustration to be used as both a high-resolution print graphic and an antialiased screen graphic for multimedia software.

Although color or gray-scale diagnostic images, photographs, and illustrations rendered on computer displays also suffer in comparison to print, the differences in spatial resolution between screen and paper are less dramatic because offset lithography requires color or tonal images printed on paper to be rendered in halftone screens (typically 150-line) that are only a little more than four times the resolution of most computer screens. However, the lower spatial resolution of computer screens is partially compensated by the availability of hundreds or even millions of colors with which to render tonal images. Thus computer displays of gray-scale or color diagnostic images often compare quite favorably to halftone or four-color reproductions printed on paper. Figure 2 illustrates the how increasing the

number of colors or shades of gray increases the density of information available from a given unit of display screen. Aside from purely aesthetic concerns, the primary advantage of a full-color display is the enormous increase in the depth and resolution of information displayed. In Figure 2 note how much high the spatial resolution of the gray-scale image is when compared to the black-and-white rendering.

Although it is rarely mentioned in the literature on computer display screens, the transmitted light ("backlighted") rendition of images on the typical computer display screen is one of the major differences between reproductions of images on the computer screen versus the reflected light viewing of images on the printed page. The greater tonal range of transmitted light more faithfully renders radiographs, magnetic resonance images, and other diagnostic images that are typically read in transmitted light (from computer screen or from light boxes) in clinical setting.

Designing for the Screen

Information-oriented graphic design in user interfaces seeks a balance between the practical necessities of information management and the esthetics of presenting text and graphics to the reader. The graphic design of a program or multimedia document is built up through the systematic use of standardized interface elements such as symbols or icons, and interactive screen elements such as windows and buttons. These interface elements are organized over a design grid similar in structure and purpose to the design grids used to create paper documents. As in print, the primary goal of graphic design for the computer screen is to establish a consistent visual structure, in which the important information is immediately obvious, and where everything else is subordinate and undistracting. Due to the relatively low spatial resolution of display screens graphics must be robust and carefully crafted to match the screen's grid of pixels. Delicate graphics or typefaces that depend on fine details not readily visible on the computer screen should be avoided. In projects that incorporate large amounts of text it is especially important to establish a clear and consistent graphic layout for text blocks, as text is much more difficult than reading text from the printed page. Abrupt or arbitrary changes in the layout of interface screens will distract and disorient the reader.

Users of multimedia computers documents don't just look at information, they interact with it in novel ways that have no precedents in paper document design. Excellence in interface design-designing how the user is able to access the information in your document-is crucial to the success of digital documents. The first design consideration in any multimedia project is to analyze the relationship between the visual and functional goals and requirements of the project and the standard interface guidelines

of the operating system (Macintosh or Windows, for instance) the project will run under. Unfortunately, inexperienced multimedia designers often ignore or are simply not aware of the existing interface design guidelines for the major graphic interfaces in use today, and thus impose a large burden on themselves and their users by attempting to re-invent graphic interface design with every new multimedia project. If you follow standard interface guidelines the vast majority of you users will easily "look through" your interface and concentrate on what's important-the information your document presents.

Many first-time designers come to process of graphic interface design committed to the goal of producing "friendly" easy-to-use software screens without balancing this against the more important goal of enticing the user with sufficient depth of content. Good interface design does not require barren screens that hesitate to provide the user with more than one or two choices at a time. While the needs of naive users are always a concern, truly naive users are increasingly rare in personal computing. Most undergraduates, nursing students, medical students, and physicians now have some experience with graphic computer interfaces and are typically more concerned with depth of content. These routine users of personal computers are likely to be annoyed by a patronizing level of "user-friendliness." By working within standard interface guidelines very complex interfaces may be built without requiring experienced users to re-learn a whole new approach to using their computers. This aspect of the visual interface design may have a crucial impact on the financial and critical success of a publication. Following interface guidelines closely should result in many fewer user support problems once the software is published. The dominant graphic user interfaces in use today (Macintosh Operating System and Microsoft Windows) have well-documented user interface standards that should be carefully considered during the initial design phase of any project for the computer screen (Apple Computer 1992; Microsoft 1992).

Although all the major graphic interfaces incorporate basic elements like windows, menus, dialog boxes, or screen buttons, each of the interfaces have particular visual design conventions that should be carefully considered and should form the foundation for the project's design grid. As in print documents, electronic documents are structured over a design grid. This "backbone" establishes where the major blocks of text and illustrations will regularly occur on the screen, and where the major screen titles, navigation buttons, and other essential elements of the screen design will sit on each of your screens. Consistency in the screen design grid is especially important because of the interactive nature of the computer interface, where visual design elements appear and disappear in response to the

user's actions. The screen grid organizes this shifting temporal quality of the screen, so that objects like windows, buttons, graphics, or text fields appear in stable, intuitive, and predictable relationships one another. The layout grid must also accommodate and standardize the locations and visual design of status indictors like special symbols or warning signs, and should define standard methods or screen locations for providing text messages and other feedback to the user. The appearance and disappearance of graphic interface elements may be thought of as a constantly shifting interactive animation. As with any animation the accurate placement of screen elements is crucial. Any slight mismatch in the location or size of interface elements as they appear and disappear will cause annoying inadvertent "animations" as the graphics shift, flicker, or wiggle in and out of registration.

The design grid must accommodate both the most and least complex layouts within the program, and must be flexible enough to allow the inevitable modifications and evolution that occurs during the construction of large projects. In large multimedia projects it isn't possible to predict in advance how every particular combination of text , graphics, audiovisual material, and interface elements will interact on the screen. The goal is to establish a consistent substructure, one that allows you to easily "plug in" text and graphics for each new screen without having to stop and re-invent your layout approach with each new design problem. Without a firm underlying design grid the screen layout will be driven by the difficulties of the moment, and the overall design may look patchy and confusing to the user.

Typography for the computer screen

Typographic design for the computer screen is difficult because of the relatively low resolution of personal computer displays. The low-contrast of reflected light LCD screens now used on many types of portable computers also severely limit type legibility in all but the best lighting circumstances. These compromises in the resolution and visual contrast of screen typography result in reduced reading speed and comprehension (Gould 1986), but proper typographic design can do a great deal relieve the difficulties of text in computer documents.

Although most standard type faces have been adapted for use in computer desktop publishing systems these faces are still primarily designed for relatively high resolution (300 dots per inch or more) use on paper. The screen fonts that accompany most PostScript typefaces often provide little more than rough previews of what the printed text will look like, and are often almost illegible on the computer screen at small point sizes. Scaleable typographic display software such as Adobe Type Manager (ATM, Adobe 1993a) or TrueType (Apple 1993; Microsoft

1993) greatly improves the rendering of larger type sizes on computer screens, but neither ATM nor TrueType software improves legibility at standard text sizes (9-12 points), and may actually decrease the legibility of some decorative or complex typefaces rendered in small point sizes on screen.

Type faces used in electronic documents should be always be judged solely by their appearance on the computer screen, and not by the esthetics of a particular font as printed on paper. The low resolution of screen displays often severely compromises the legibility of condensed, light, extended, or decorative typefaces. In general typefaces designed for maximum legibility in low resolution displays have relatively large x-heights, simple character shapes, and each of the smaller font sizes (9, 10, 12 points) is specially optimized for legibility on the screen. Proportionately spaced typefaces such as the standard Macintosh screen face Geneva or New York (Apple computer 1993), MS Sans Serif or MS Serif (Microsoft 1993), or Adobe's Stone and Lucida PostScript typeface families (Adobe 1993b) are were specifically designed the be legible in a wide variety of low-resolution media.

Because the typography within an electronic document currently depends on the typefaces present in the operating system of the computer the designers of electronic documents face problems unique to the computer screen (Brown 1991). Typographic layouts on the computer screen are created anew by the computer's operating system each time a document is displayed on the screen, using font resources from the operating system and the text fields built into your electronic document. Because the typography is dependent on variable factors like the presence or absence of specific fonts within the system, or the presence of font-scaling software like ATM or TrueType, the precise layout of your text blocks, titles, and other screen type may vary. Usually text in long text blocks will not shift too radically in position or legibility, but text in small labels or tightly-cropped titles may be drastically affected by even small changes in font geometry is you do not leave enough space within the text field for the text to expand slightly. If tightly-cropped text is displayed in slightly expanded form the text may not fit into the field, and either drop down to the next line, or simply disappear because it no long fits in the text field.

Although almost every popular typeface in current graphic design is now available in PostScript or TrueType form for the computer screen the choices available to electronic publishers are often limited by practical concerns to just those type faces supplied by the operating system manufacturers with the system software. If you chose a typeface not present in the standard set supplied with the operating system the typeface must be supplied with the electronic document, and this may require the user to take extra steps (which they may or may not bother with) to

install the font into the operating system. Prior to Macintosh System 7.1 it was possible to install Macintosh screen fonts into the resource fork of HyperCard or SuperCard documents, but recent changes in the operating system's handling of font resources has removed this option. If the font you have chosen for the text in your electronic publication is not present in the operating system another font will be substituted, often with disastrous effects on precise typographic layouts. However, the recent advent of highly scaleable multiple-master font technology will make it possible to a standard set of built-in fonts to (approximately) emulate the look and geometry of all but the most complex or decorative typefaces (Fenton 1992).

Currently the growth of electronic publishing is crippled by the lack of wide accepted file formats that can be used on many different types of computers or digital audiovisual display hardware. New cross-platform software technologies are now becoming available to standardize the layout and typography of screen documents, regardless of the computer or operating system in use. Adobe's Acrobat software uses the PostScript page description language and a new file format (Portable Document Format, or PDF) to allow documents with sophisticated layout and bit-mapped or object-oriented graphics to display properly on many different computer systems, even if the systems lack the proper fonts to display type (Adobe 1993c). Future version of Acrobat will allow complex text search and retrieval, and incorporate digital sound and video information. While this will solve some of the practical problems of electronic publications, designers who require specific typefaces within complex typographic designs will continue to face difficulties until the designers of computer operating systems address this issue. When in doubt, restrict your typefaces to those built into the operating system of the computer.

At standard screen reading distances text blocks should be set at a minimum of 9 points, with relatively generous leading (9/13, or 9/14) to improve the legibility of small print. Increased line spacing, especially when used in 10 or 12 point sizes can greatly improve reader speed and comprehension (Human Factors Society 1988). HyperCard (Apple Computer 1991), SuperCard (Aldus 1991), and most other multimedia authoring tools allow several tricks that can increase the legibility of long blocks of text on the computer screen. Leading (or "line height" as it is called in HyperCard) is a traditional typographic term referring to the amount of space between each line of type. HyperCard allows you to easily control the amount of leading in text fields. A good rule of thumb in smaller text sizes is to use a "line height" or leading 3 to 4 points greater than the size of the type. For example, for 12 point type choose 15 or 16 points of leading. The extra line spacing makes scanning across the lines of type easier on the eye, and can

actually make the type appear larger than it really is. The standard type controls in multimedia authoring programs also allow you to slightly expand the horizontal dimension of a typeface by selecting the "Expand" box in the list of type style options. Slightly expanding the horizontal dimensions of a suitable screen type face is a good trick for making thicker or boldface fonts more legible, and can sometimes make very small type sizes a little easier to read.

Many of the typographic rules and standards used conventional print media also apply to text layouts for computer screens. The optimum line length for a text block should always be proportional to the size of the type font in use. Column widths of 40 to 60 characters provide optimal line lengths for legibility (Horton 1991). If the column length is too short relative to the size of the text there will be inadequate room for proper word spacing. Many multimedia authoring systems provide a "wide margins" option as a standard visual option when formatting text fields. Because text in computer systems is often contained within windows that may be dynamically resized and moved about the screen, the margins around a text block should be generous enough to provide adequate visual separation between the text field and other background objects.

Spatial relationships in the interface

Our day-to-day visual experience conditions us to believe that dynamic, interactive objects naturally exist three-dimensional space, and have logical visual and spatial relationships to one another. In graphic user interfaces screen objects show their spatial relationships by overlapping one another, scrolling off the screen "somewhere else," cast drop shadows, change in size, zoom in magnification, and objects sometimes appear to distance themselves from the viewer by "graying out" when inactive. We have no real-world experience with such highly dynamic objects that exist only in the two-dimensional flatland of the computer screen, and so interactions with interface objects seem to occur within a special spatial framework unique to graphic interfaces. From the visual designer's point of view the computer screen may be best though of as a representation of a shallow space. In this form of graphic representation objects have a definite spatial relationship to one another, and their graphic representations should consistently reflect the spatial relationships implied by the interaction of "near" and "far" objects. Most multimedia documents also "layer" information related to the current topic by hiding windows or other objects until the user requests that specific information (see Figure 3). In current graphic user interfaces the visual layering techniques are limited and relatively crude; superimposing objects is still the primary means of visual layering in graphic interfaces The illusion of

three-dimensional space is limited, and results in complex, confusing screen displays when many windows are layered in multitasking environments like the Macintosh (Fig. 3, right side).

Depth cueing by varying the color saturation of objects has been used for centuries by landscape artists to suggest great expanses of space within painting. The painters noticed that the atmosphere causes faraway objects to lose color saturation and visual detail, and that mimicking these natural visual effects could produce paintings with the illusion of great distance. This same effect is useful for visual layering in the user interface, where important "foreground" objects should be rendered in strongly contrasting hues. Background or unimportant elements may be visually shifted back away from the user by rendering them in desaturated colors of shades of gray. Gray backgrounds are often gentler on he eye than the bright "paper white" backgrounds now seen in both the Macintosh and Windows graphic interfaces.

Three-dimensional spatial representations also complement and reinforce interface metaphors. Users assume that interface elements rendered as three-dimensional objects will function much like their real-world counterparts. Thus control panels, buttons, and other interface objects meant to be "manipulated" or clicked on are often rendered as if they existed as real three-dimensional objects (see Figure 4). A simple line rectangle on the computer screen is spatially and functionally ambiguous; if the same rectangle is given a beveled edges and cast shadows like an physical button the user is much more likely to treat the "virtual button" as a dynamic, interactive part of the graphic representation on the computer screen.

Symbols and semiotics in the interface

Graphic symbols have long been used by industrial designers to suggest the function controls and buttons in a compact, nonverbal manner (Meggs 1989). User interfaces are dominated by nonverbal symbols, icons, pictograms, and other graphic metaphors, and the design of visual interfaces usually involves creating new symbols or adapting existing ones to represent standard actions and elements within the program. Figure 5 illustrates a typical screen from a multimedia program designed as a teaching resource for cardiothoracic imaging. The row of three button icons at the lower right represent standard features of the interface such as opening a magnified "zoom" window of the radiograph, showing labels on the radiograph, and opening a window with case notes. Semiotics, the study of signs, symbols, and their use and meaning (Eco 1976) has had a powerful impact on the designers of graphic symbols and typography. Semiotics has been advocated as a analytical tool and guiding principle in the visual design professions (Ashwin 1989) and particularly in

the design of graphic user interfaces (Marcus 1992). The careful, systematic application of graphic symbols and icons is crucial to the success of interface design (Schneiderman 1992). Graphic interfaces and other symbolic design systems are not inherently "user-friendly," and a poorly designed interface can rapidly deteriorate into an elaborate digital rebus of cryptic symbols in ambiguous relationships (Lupton 1989; Nelson 1990).

Summary

Digital media are not just audiovisuals played on computer screens. Complex electronic documents may be a mixture of all forms of communications media, delivered in a highly dynamic, interactive form that challenges many of the basic tenets of audiovisual and graphic design. The most powerful forms of electronic documents are those that incorporate "live" data links from high-bandwidth optical fiber computer networks such as those now being assembled in the High-Performance Computing Initiative. These multimedia books and magazines will challenge the very definition of "publication" because they will not contain static content nor will they exist in multiple copies. There may be only one copy of most "publications" in existence, and all access to these on-line publications will flow from source to user through digital networks. Documents that incorporate live network links will dynamically change their content over time, in response to built-in instructions to seek out specific information from network sources at frequent intervals. Documents that attempt to assemble multiple forms of information that is in continual flux will be the ultimate challenge for graphic designers and audiovisual professionals. At the level of individual hospitals most medical records and patient information will eventually exist as live documents that continually search the both the local hospital information systems and national data sources such as Medline for information relevant to the care and treatment of that particular patient.

As digital multimedia documents and publications become the dominant communications medium in the biomedical sciences, the design and production of and electronic documents will soon dominate and perhaps subsume many of the audiovisual professions within biomedical communications. This does not mean that the core skill disciplines of biocommunications will disappear-but the advent of such a powerful new communications medium will have profound effects on both the way we practice our individual disciplines, and create the need for new biocommunications professionals whose primary function is to design and produce digital multimedia documents and publications. Although most of the fundamental audiovisual design and production skills are equally applicable to

these new media, the highly interactive nature of electronic documents will make human interface design an essential skill in biocommunications.

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Evolving multimedia

The Evolving Interface of Multimedia

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Graphic user interfaces now completely dominate the personal computer marketplace. But ironically, just as the Macintosh and Windows interfaces are becoming more similar to each other, a distinct style of multimedia interface is emerging to challenge both the Macintosh and Microsoft Windows for the ownership of your screen. By removing the menubar and taking over the whole computer screen, most of today's multimedia CD-ROM interfaces simply abandon both the Macintosh and Windows interfaces, substituting intense visuals, video clips, and animations for the more functional (if more mundane) windows, pull-down menus, and standard buttons of the mainstream graphic interfaces. The differences between most multimedia CD-ROM interfaces and those seen in mainstream Mac and Windows applications represent much more than an attempt to enliven the computer screen with visual sensation instead of information. In drawing their screen metaphors and graphic design from the worlds of television, video games, and film, many multimedia producers have (consciously or unconsciously) adopted a paradigm for interacting with computers that is fundamentally different from that envisioned by the designers of today's Mac and Windows graphic interfaces. The basic question in multimedia publication design is this: are tomorrow's multimedia computers going to behave like televisions with keyboards, or will we treat them more like personal computers that can also deliver complex audiovisuals?

Today's Mac and Windows graphic interfaces grew out of attempts to provide the computer user with a wide range of easily accessible and understandable choices when interacting with a computer. Although your first graphic interface may take some effort to learn (the ease of use claims for graphic interfaces have always been vastly overstated), once you are familiar with the Macintosh or Windows GUI you can cope with very complex interactive environments as long your software consistently stays within the basic interface guidelines of the operating system.

While the graphics of multimedia may be rich, the opportunities for interactions and navigation in most multimedia programs are often surprisingly limited. Compared to the average word processing program or spreadsheet most multimedia programs offer pathetically few choices to the multimedia user. For example, Microsoft Word (Mac or

Windows version) offers almost 120 direct menu choices and another 50 options on graphic tool bar. If you count the indirect options available through the dialog boxes opened by most menu items, Word actually offers hundreds of opportunities for choice and interaction. By contrast, popular multimedia CD-ROMs like Alice to Ocean rarely offer the user more than six to ten potential choices at any time. In most screens the only choice is to go on, or return to a graphic "menu" or "contents" that lists a half dozen options. And graphic menus are so slow! Forcing the user to rely on graphic menu screens instead of standard GUI menu bars and pull-down menus only exaggerates the slow response time of the CD-ROM player. Instead of the quick snap of a pull-down menu, the user sits watching a watch or hourglass cursor while the CD-ROM drive desperately grinds out another visually beautiful but functionally impoverished menu screen (300K of drop-dead graphics, .01K of navigation options).

The passive, linear medium of television is the worst possible metaphor for a truely interactive medium, and interactive cable systems will never offer tha range of sophisticated fucntionality and interaction we now expect from desktop computers. Only the computer, with its almost infintely plastic range of interface behaviors and interactive possiblities can deliver the type of complex audiovisual environments envisioned by today's multimedia developers. Multimedia computers are not televisions with keyboards!

The evolution of standards

The marketplace for electronic publications is rapidly maturing, and CD-ROM's will shortly lose their novelty and become a routine source of information for computer users and educators. As this happens the publishing industry will begin to impose minimum standards for organization and useability for electronic publications comparable to those seen in conventional (paper-based) publishing. Currently there is no Chicago Manual of Style to consult when constructing a multimedia CD-ROM. However, the interface design guidelines for the Macintosh and Windows operating systems offer a ready framework for the construction of publications that can incorporate complex levels of interactivity and choice without overwhelming the user. The users of Mac or Windows systems already know how to use their computers, but multimedia programs typically remove the standard interface and force them to re-learn basic navigation with every new CD-ROM title they open. Beautiful photographs and digital videos are not a substitute for quick, understandable document organization and familiar graphic interface conventions. The lessons from the sales of mainstream "office productivity" software are clear: non-standard interfaces are quickly driven out of the market. CD-ROM readers will

increasingly resent multimedia documents that wipe away the menubars, windows and desktops of their familiar computing environment, only to impose a slow, inconsistent, and patronizing level of interactivity.

While multimedia CD-ROM's are rapidly becoming routine in mainstream publishing, the creation of multimedia tools is still dominated by software programmers who have little experience with or understanding of editorial process, document design, graphic design, or publication management. Basic provisions for automated indexing and table-of-contents generation, control of versioning and text edits, hot links to multimedia content databases, multi-user server-based authoring for workgroups, and sophisticated overview tools for viewing the broad outlines of project structure are all hampering the development of editorial workgroups for multimedia publishing. Ironically, many of these same editorial management features have been available for some time to users of PageMaker and Quark XPress. Adobe has begun to move toward implementing of it's Acrobat "PDF" file format for multimedia electronic documents in mainstream applications like Adobe Illustrator and Aldus PageMaker (now also owned by Adobe). If the makers of multimedia authoring don't wake up and get serious about the editorial needs of publishers they may find that two years from now their main competitors for CD-ROM authoring will be Adobe PageMaker and Quark XPress. Imagine a single document that could provide full cross-platform interactive multimedia functionality on the computer screen AND be could printed on paper for conventional publication that would be real multi-media and would signal the advent of mature multimedia publishing tools.

The creators of the currently available authoring tools for multimedia have rarely put much thought or effort into tools for interface design or document organization. The dominant use for authoring tools is in audiovisual presentations for business and authoring for CD-ROM publications that emphasize media audiovisual glitz over information. Unfortunately, it is rare to find non-fiction "edutainment" CD-ROM titles that offer anywhere near the depth or organization of content that books on the same topics offer. This could be because the CD-ROM buying public is still infatuated with the novelty of electronic documents. However, it won't take long to for people to begin asking why they are expected to pay double or triple the price of a book for CD-ROM based information that often has no index, no table of contents, no page numbers or other systems to mark the location of particular bits of information, and only the most limited range of interactive functionality.

Templates for multimedia authoring

The design of multimedia documents is rapidly evolving, but

most new users of multimedia authoring tools are immediately stymied by the need to reinvent the whole business of electronic document design before they ever get down to the task of assembling their content with the authoring software. It's odd that the makers of most multimedia authoring tools have never offered users a range of ready-made templates for multimedia content similar to the basic document templates that have been available for years in desktop publishing. Most buyers of multimedia authoring tools have no ambition to become experts multimedia producers, graphic designers, or human interface experts they just want to deliver a given set of information in a professional and efficient manner. These users would benefit enormously from professionally-designed templates that have most of the screen layout, document structure, and basic scripting of the user interface already completed and ready to customize. Various styles of multimedia interfaces could be accommodated in different templates, from mainstream menu-and-window driven Mac or Windows interfaces to simple point-and-click interfaces with graphic menu screens that users could customize very quickly for their own projects.

Where are the publishers?

So far the multimedia marketplace has been dominated by software developers, game designers, and audiovisual producers, yet we are continually told that the largest future impact of multimedia will be in the publication and dissemination of information that is now printed on paper. It's the publishing industry that will eventually have the biggest stake in the success of electronic publishing, yet the industry seems to have had virtually no impact on the development and future of authoring tools or interface standards for electronic information. The crucial multimedia authoring features for publishers will center around networked access to information, and the design of consistent, familiar user interfaces to vast commercial on-line libraries of information. In a world that will soon be dominated by high speed fiber-optic networks linking every home and business, CD-ROM will fade to insignificance as a publication medium. Networked multimedia documents produced by publishers will need to be assembled by teams of authors, audiovisual producers, and other media and software professionals, using authoring systems based on a consistent user interface and file structure across the whole range of the editorial process, from the personal computers of individual authors to the supercomputer-based file servers that will actually "publish" the edited final document. Interface design will be the crucial competitive arena on-line publications will only be successful if users can find the information they want quickly and easily, using graphic interfaces derived from mainstream Mac or Windows standards.

As the multimedia authoring market continues to mature, title construction tools that support the full range of Macintosh and Windows interface behaviors will be essential. As mentioned last month in this column, Asymetrix's ToolBook and Allegiant's SuperCard are showing welcome signs that authoring tool makers are beginning (just barely) to look beyond basic graphics and media features and are starting to tackle the more important job of providing serious content developers with sophisticated editorial environments that support the mainstream graphic user interfaces.

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Adobe Systems, Inc. 1993. *Adobe Premiere: Classroom in a book.* Mountain View, CA: Adobe Press.

Adobe has produced three excellent book-length tutorials on its major software products, Illustrator, Photoshop, and Premiere. Each comes with its own CD-ROM of example files and tutorials. Well written, highly recommended for quick-starts into these complex but essential imaging tools.

HIGHLYRECOMMENDED

Apple Computer, Inc. 1992. *Apple CD-ROM Handbook.* Reading, MA: Addison-Wesley.

An excellent introduction to the basic technology of CD-ROM production. Covers both authoring and content issues and CD technology, in a (mostly) non-technical style.

Bennet, H. 1993. PhotoCD: A Macintosh primer. *CD-ROM Professional* 6 (4): 93-101.

Introduction to the technology and uses of Kodak's PhotoCD CD-ROM format for digital photography.

Bove, T. and C. Rhodes. 1990. *Using Macromind Director.* Carmel, IN: Que Corporation.

One of the very few third-party books on Macromedia Director. Although this book only covers version 2.0, most of the Director interface is still similar enough for the book to be a useful companion to the current version 4.0 manuals.

HIGHLYRECOMMENDED

Cohen, L. S., R. Brown, and T. Wendling. 1993. *Imaging essentials.* Mountain View, CA: Adobe Press.

Excellent introduction to the technology, software, and processes in electronic imaging and computer illustration. The best single reference I've seen to the common image formats used in electronic design. Also has excellent illustrated explanations of the complex filtering and channel operations possible in Adobe Photoshop.

HIGHLYRECOMMENDED

Dayton, L. and J. Davis. 1993. *The Photoshop wow book.* Berkeley, CA: Peachpit Press.

Although Photoshop's manual and tutorial is excellent, the program is so complex and can be used in so many different contexts that it is useful to have third-party books like this one

around to see what other people do with Photoshop. Well written and illustrated.

Drucker, D. L., and M. D. Murie. 1992. *QuickTime handbook.* Carmel, IN: Hayden Press/Prentice Hall.

Well-written, not overly technical overview of Apple's QuickTime digital video technology for the Macintosh. Covers the major video concepts and hardware tools, video digitizers, and video editing software like Premiere, VideoFusion, and Videoshop.

Goodman, D. 1993. *The complete HyperCard 2.2 handbook,* 3rd ed. New York: Bantam Books.

The granddaddy of all scripting handbooks. Goodman explains things very well, and the book is well organized for quick reference to specific topics and problems. Since HyperCard, SuperCard, and Director all share similarities in their scripting languages, this book is useful even if you don't actually use HyperCard.

Horton, W. K. 1991. *Illustrating computer documentation.* New York: Wiley.

An excellent book with a dry, somewhat misleading title. This book actually covers many general issues of graphic design, for both paper documents and the computer screen. Horton always cites his sources in academic style, so the bibliography here is also quite valuable.

Jerram, P. and M. Gosney. 1993. *Multimedia power tools.* New York: Random House.

A very good overview of current (Macintosh) multimedia software, hardware, and technology. The best single-volume survey of multimedia for the Macintosh. Very comprehensive listings and short reviews of authoring tools and graphics software. The companion CD-ROM suffers from a slow and very mediocre user interface, but contains lots of public domain and demonstration tools.

Jerram, P. 1994. CD-ROM universe. *NewMedia* 4 (6): 40-46.

An excellent overview of the current state of the CD-ROM publishing industry, with interesting data on the average budgets for major CD titles. A related article in the same issue covers CD distribution channels, partnerships, and CD publishers.

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Johnson, N., F. Gault, and M. Florence. 1994. *How to digitize video.* New York: Wiley.

The best single-volume reference I've seen to date on the tools and technology of digital video. Covers both Mac and windows versions of QuickTime, as well as Microsoft's Video for Windows AVI standard.

Kiamy, D. 1993. *High-tech marketing companion.* Reading, MA: Addison-Wesley.

A compilation of short articles on the business of software and hardware marketing and distribution. A good introduction to some of the realities of publishing software, getting a distributor, and properly packaging your products for the Mac and PC marketplace.

Lipson, S. 1994. *Windows as a second language.* Alameda, CA: Sybex.

Being a serious multimedia publishers means reckoning with "that other platform." If you are a hapless Mac user (like me) forced by circumstances to deal with Windows you will find this book both helpful and entertaining. Given the GUI design edge the Mac has, I doubt if Windows users would even need an equivalent Windows-to-Mac translator.

Lynch, P. J., C. C. Jaffe, P. I. Simon, and S. Horton. 1992. Multimedia for clinical education in myocardial perfusion imaging. *Journal of Biocommunication* 19 (4): 2-8.

A brief paper on how we used multimedia to create an extensive atlas of digital medical imaging.

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Overview of PhotoCD technology and uses, especially as applied to the Macintosh and Mac imaging software.

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Graphic and industrial design firms are entering the business of user interface design; the emerging field of software design.

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Roundtable discussion among 13 multimedia designers, graphic designers, and electronic publishers on the design implications of multimedia.

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A good introduction to the basics of graphic presentation to audiences. Oriented more to speaker support issues than to multimedia design, but many of the design problems are the same, and many multimedia programs will be used as interactive speaker support "slides" anyway.

Rosenthal, S. 1994. Electronic publishing. *NewMedia* 4 (7): 44-47.

Good overview of the current state and near future of electronic publishing, especially as compared to paper-based publications. Short articles on CD publishing standards and CD-ROM packaging follow.

Spanbauer, S. 1993. The write stuff: CD-recordable. *NewMedia* 3 (10): 62-68.

A brief survey and explanation of recordable CD-ROM ("CDR") technology and potential uses. Anyone interested in CD-ROM publishing or large multimedia productions needs at least a basic understanding of CDR, which is quickly becoming an essential prototyping and mass storage medium.

HIGHLYRECOMMENDED

Spiekermann, E. and E. M. Ginger. 1993. *Stop stealing sheep.* Mountain view, CA: Adobe Press.

An excellent book on the uses and abuses of typography. Don't be put off by the odd title. This is the best recent book that I've seen on typography.

Apple Computer, Inc. 1989. *HyperCard stack design guidelines.* Reading, Mass.: Addison-Wesley.

The "file card" metaphor introduced by HyperCard in 1987 has become the dominant theme in multimedia authoring systems. This book is an excellent guide to the user interface design considerations necessary when designing any graphic interface for the computer screen. It also contains discussions of how multimedia affects user interface design, and the design problems presented by interactive sound and music in computer presentations.

Apple Computer, Inc. 1992. *Macintosh human interface guidelines.* Reading, MA: Addison-Wesley.

This volume is Apple's standard guide to the graphic user interface of the Macintosh computer. This book is an excellent introduction to the design principles that underlie all graphic user interfaces, as the Macintosh "desktop" interface is by far the oldest and most highly evolved of the graphic user interfaces now on the market.

Apple Computer, Inc. 1993. *Making it Macintosh. The Macintosh interface guidelines companion.* CD-ROM. Reading, MA: Addison-Wesley.

Designed as an interactive companion to the Macintosh Interface Design Guidelines. Has well-organized screens and excellent graphic design, but strangely, the program makes minimal use of the Mac interface.

Blattner, M. M., and R. B. Dannenberg, eds. 1992. *Multimedia interface design.* Reading, MA: Addison-Wesley.

A compilation of research papers in interface design and human-computer interaction in multimedia system. Most of the papers are dry and quite technical, but the book is good as a concise reference to a spectrum of research interests in the professions of interface design and multimedia interfaces.

Grudin, J. 1990. The computer reaches out: The historical continuity of interface design. In *Empowering people: CHI '90 conference proceedings.*, ed. J. C. Chew and J. Whiteside. 261-268. Reading, MA.: Addison-Wesley.

A concise overview of the development of graphic user interface concepts and technologies, starting in the mid-1960's with pioneering work by Doug Engelbart (inventor of the mouse) and Ivan Sutherland (inventor of interactive computer graphics).

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This is a brief survey of the major graphic user interfaces currently in use, including screen shots of each interface.

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This chapter covers some of the history of computer-aided instruction in medicine. Very good summations of the advantages and problems inherent in teaching medicine with computers.

HIGHLYRECOMMENDED

Horton, W. K. 1994. *Designing and writing online documentation, 2nd Edition.* New York: Wiley.

A superbly researched book covering virtually every facet of computer document design. Horton uses academic-style literature citations liberally throughout the book, so if you are interested in pursuing some specific topic you can easily find out who Horton is citing as a source. The book's bibliography alone is worth the $29.95 cover price.

HIGHLYRECOMMENDED

Horton, W. K. 1991. *Illustrating computer documentation.* New York: Wiley.

A very practical volume, full of immediately useful and practical advice on computer document design. This book covers a wide variety of topics in visual literacy. Illustrators and graphic designers may find some of the points self-evident or tedious, but the book covers so much useful material that this doesn't really detract from the overall value. Again, Horton's bibliography is extremely thorough, and well worth the price of the book.

Laurel, B., ed. 1990. *The art of human-computer interface design.* Reading, Mass.: Addison-Wesley.

An interesting compilation of 55 short articles and essays on various aspects of human-computer interaction. The book gives an excellent plain-English (minimal level of tech jargon) overview of human interface design problems, and the design of computer documents.

Laurel, B. 1991. *Computers as theater.* Reading, Mass.: Addison-Wesley.

Laurel has many interesting things to say about the nature of human-computer interaction, and how dramatic metaphors can help clarify how people react to and work with their computers. This is NOT a how-to book of practical advice, but if you are interested in the possible futures of human interface design this short book is an interesting read.

Lynch, P. J. and C. C. Jaffe. 1990. An Introduction to Interactive Hypermedia. *Journal of Biocommunication* 17 (1): 2-8.

A review article describing how hypertext and hypermedia metaphors can be applied to medical teaching problems. Describes the basic structure of hypertext systems, and how audiovisual computing techniques can extend the hypertext metaphor into multimedia documents.

HIGHLYRECOMMENDED

Marcus, A. 1992. *Graphic design for electronic documents and user interfaces.* New York: ACM Press, Addison-Wesley.

A very well-written book on the theoretical basis and practical problems associated with computer document design. Marcus' outline for a computer document design program is especially useful, outlining many of the design features that should be specified in a thorough interface design program.

HIGHLYRECOMMENDED

McCloud, S. 1993. *Understanding comics: The invisible art.* Northhampton, MA: Kitchen Sink Press.

A superb book-length graphic essay (McCloud uses comics to explain graphic communication). Fast becoming a classic in graphic communications, both for McCloud's insights into graphic form and communication, and because the book is self-exemplifying as a graphic narrative.

Microsoft Corporation. 1992. *The windows interface: An application design guide.* Redmond, WA: Microsoft Press.

On of the few existing books dedicated specifically to Windows interface design. Well written and organized.

HIGHLYRECOMMENDED

Norman, D. A. 1988. *The psychology of everyday things.* New York: Basic Books. (Now sold in paperback as The Design of Everyday Things.)

This little book is already considered a modern classic in the industrial design and human interface design professions. Norman is a cognitive psychologist, and his book is a highly readable examination of why certain kinds of manufactured

things work well and are easy to understand, and why other things (like computers and VCR's) are often so poorly designed and difficult to use. If you pick one book off this list to read, PICK THIS ONE.

Norman, D. A. 1992. *Turn signals are the facial expressions of automobiles.* Reading, MA: Addison-Wesley.

A compilation of short essays on industrial design and human-technology interactions. Highly readable, plain-English wisdom on the design of computers, consumer products, and high technology.

HIGHLYRECOMMENDED

Norman, D. A. 1993. *Things that make us smart: Defending human attributes in the age of the machine.* Reading, MA: Addison-Wesley.

An extension of Norman's earlier books, this time focusing specifically on the uses, human interface issues, and societal problems of computers and high technology.

Schneiderman, B. 1992. *Designing the user interface.* 2nd Ed. Reading, Mass.: Addison-Wesley.

Schneiderman is one of the leading academics in human-computer interface design. This somewhat technical book gives a good overview of interface design developments during the 1970's through the early-1990's, and contains many useful explanations of the philosophical and research underpinnings of graphic interface design.

Shortliffe, E. H., and L. E. Perreault, ed. 1990. *Medical informatics: Computer applications in health care.* Reading, MA: Addison-Wesley.

This volume is an excellent introduction to the wide range of topics now lumped under the umbrella term medical informatics, including hospital information systems, bibliographic research systems like MEDLINE, digital radiology systems, picture archiving and communication systems (PACS), and other many topics involving the use of computers in medical environments. The best single-volume introduction to medical informatics available.

HIGHLYRECOMMENDED

Smith, D. C., C. Irby, R. Kimball, and B. Verplank. 1982. Designing the Star user interface. *Byte* 7 (4): 242-282.

This article is a GUI classic. It was written by the principle designers of the Xerox Star graphic user interface developed at

Xerox's Palo Alto Research Center (PARC) in the mid 1970's. This is the interface work everyone else (Apple, Microsoft, etc.) has copied and adapted into today's current Mac and Windows GUI's. The article covers all of the basic ideas that underlie the graphic metaphors for human-computer interaction, and how those ideas were implemented on the Xerox Star computer. Highly readable, with minimal technical jargon.

Tognazzini, B. 1992. *Tog on interface.* Reading, MA: Addison-Wesley.

For fifteen years "Tog" Tognazinni was Apple's chief interface advocate (he has since left Apple and now works at Sun). This book is a lively, informal series of essays on a wide variety of interface design issues. Not a book to refer to for carefully organized prescriptions on interface problems, but good fun to read anyway.

HIGHLYRECOMMENDED

Tufte, E. R. 1983. *The visual display of quantitative information.* Cheshire, CT: Graphics Press.

Tufte's book is now widely regarded as the best work that has ever been done on the design of data graphics. Full of well designed and superbly printed illustrations of Tufte's likes and dislikes in data graphics. Don't be put off by the title; the text is very well written and not particularly technical.

HIGHLYRECOMMENDED

Tufte, E. R. 1990. *Envisioning information.* Cheshire, CT: Graphics Press.

This book is the best single-volume textbook on visual literacy that I know of, covering conventional graphic design issues, quantitative data graphics, and also includes Tufte's thoughts on human interface design for the computer screen. Superbly illustrated with many graphic examples.

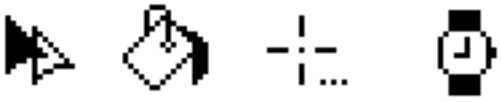
Weiser, M. 1991. The computer for the 21st Century. *Scientific American* 265 (3): 94-104.

The author is one of the current researchers at Xerox's Palo Alto Research Center (PARC), and he describes PARC's current work on new computing software and hardware paradigms. Weiser advocates what PARC calls a "ubiquitous computing" model, where offices and other work environments might be full of many small computers that will all interact and communicate to aid people in creating and using information. Weiser's model is especially relevant to medical environments, and may be the most realistic scenario for the future of medical computing.

Buttons
A rectangular graphic that is usually labeled with text to indicate its function. Buttons usually perform an instantaneous action to initiate or conclude a process.

Check boxes
Used when alternatives are not mutually exclusive, or may be applied simultaneously, such as type styles: type can be both bold and italic at the same time. Check boxes never initiate or conclude an action, they are only used to set choices.

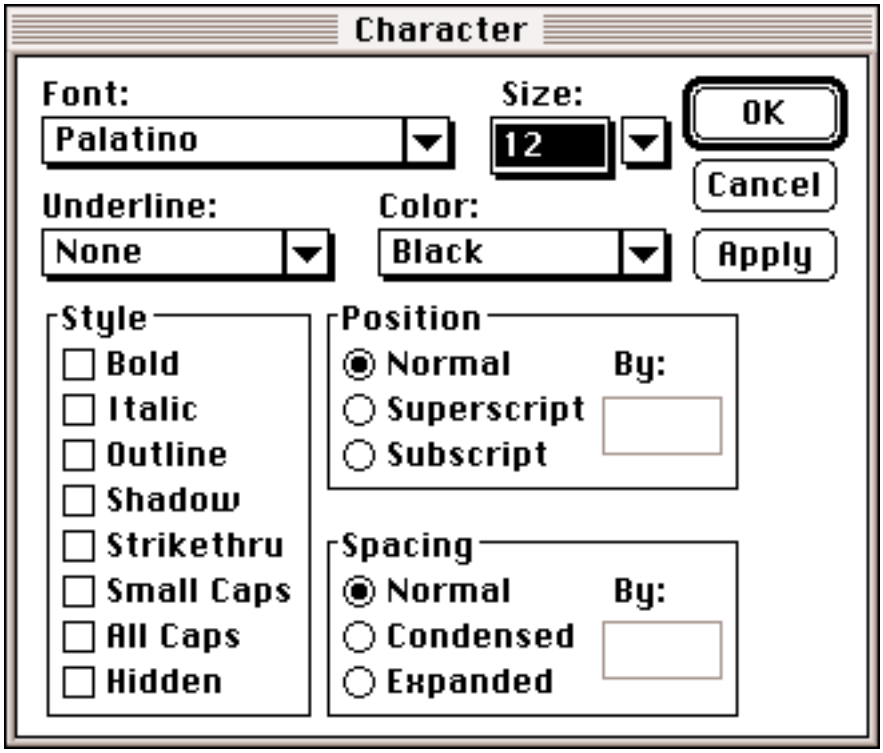
Cursors (or pointers)
An extremely important but often overlooked component of graphic interfaces. Cursors indicate the point of action or insertion on the screen, often acting as a virtual manipulator or hand tool for moving and editing on-screen objects. Cursor are often used to indicate the state of the system (watch or hourglass cursors indicate a short pause, for example), or change to indicate a change in the interactive possibilities offered by the interface (like the window resize arrow cursors that appear at the edges of windows in the Microsoft Windows interface).



Default buttons
A screen button with a heavy outline used to indicate the most likely action to be taken (as long as there is no danger that the action will result in the loss of the user's data). Default buttons are usually linked to the Return key of the keyboard; to initiate the default action the user can just hit the Return key.

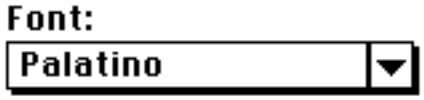
Dialogboxes
Special windows that pop up to provide information or choices to the user. Dialog boxes are usually modal, that is, they must be dismissed (with the "Cancel" or "OK" buttons) before further action can take place. Some dialog boxes provide many buttons, pop-up menus, or other choices; others may just contain a text message with an "OK" button used to dismiss the dialog box.

Note the way check boxes, radio buttons, buttons, default buttons, pop-up menus and text fields are used in this dialog box examples below. These interface elements form the visual and functional vocabulary of the graphic interface, and should only be used in accordance with the interface guidlines of the operating system you are designing within.

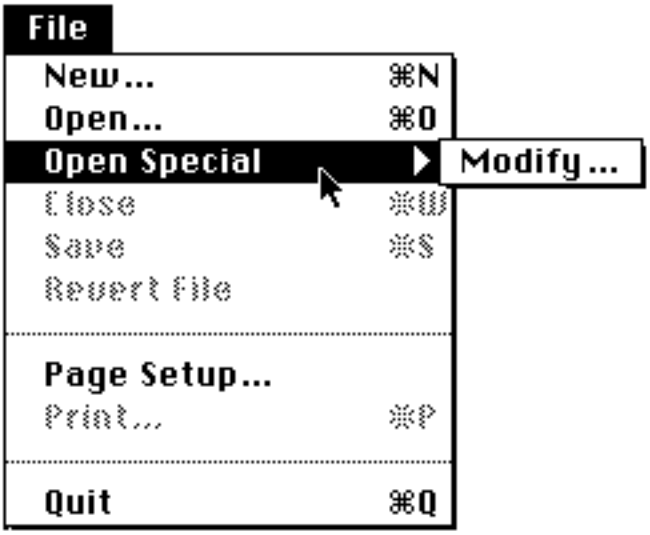


Icons
Graphic representations of objects in the computer interface, including folders, documents, trash cans, mail boxes, applications, storage media, and other hardware attached to the computer or the computer network.

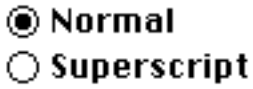
Pop-up menus
Often used in dialog boxes to provide a list of mutually exclusive choices; a more compact choice than listing the items as radio buttons. Pop-up menus are indicated in both the Mac and Windows interfaces by rectangles with downward-pointing arrows.



Pull-down menus
Menus that drop down from the menu bar at the top of the screen (Mac interface) or top of the window (Windows interface). Menu selection usually initiate some action directly. Menu items that open a dialog box for further information are indicated by placing an ellipses after the item name (for example, "Print..." opens a dialog box that solicits further information before printing actually takes place). Dividers are used to logically group menu items, or may simply provide visual relief in long menus. Submenus (such as the "Modify" submenu shown at the left) are a means of multiplying the number of menu items available. However, multiple submenus, or triple-layered submenus require to much dexterity for most users and most interface guidelines discourage nested submenus.



Radio buttons
Denote mutually exclusive choices. Used in situations where only one setting can be active at a time. Name is derived from the metaphor of car radio buttons, where only one radio station can be selected at a time. Radio buttons never initiate or conclude an action, they are only used to set choices.



Window styles
All interfaces provide a number of standard window styles. Window styles also incorporate standard interface elements such as scroll bars, close boxes, pop-up menus, and "zoom boxes."

Note that these (Macintosh) window styles shown above are not just visual alternatives. Each style of window implies a range of interface behaviors as well. For example, "Palette" windows should always float above other windows and are never overlapped (except by other palettes). Modal windows force the user to take a specified action to dismiss the window before any further interaction can take place.

Contents

Appendices

Literature cited
Multimedia bibliography
Interface bibliography
Interface glossary
Web authoring sites

C/AIM

This is a brief compilation of on-line resources we have found useful. For books and print references, see the bibliography.

[This section needs a total overhaul]

Web style guides

HTML resources

Other authoring resources

Contents

Download & printing

Downloading options

Printing Options

This Web style guide is available in its entirety as HTML files and graphics. You are free to download the guide for personal use, or to mirror the guide on your local Web intranet server, with the following restrictions:

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Anonymous FTP
Version 2.0, beta.02

Host: info.med.yale.edu
User: anonymous
Password: your email address
Directory: /pub/caim/
The subdirectory "manual" holds the style guide files.

CuteFTP application for Windows95 (484 KB file)

Fetch (FTP utility for Macintosh) (604 KB file)

Windows95/NT*
Version 2.0, beta.02

Use anonymous FTP (see above)

*The file names used in the guide do not conform to the "8.3" naming restrictions in Windows 3.1 or MS-DOS, therefore the HTML links will not operate properly in older versions of Microsoft Windows, or in MS-DOS.

Macintosh
Version 2.0, beta.02

binHex format, StuffIt (.sit) compressed (15.6 MB file)
MacBinary, StuffIt (.sit) compressed (11.9 MB file)
StuffIt Expander application for Macintosh (269 KB file)

Unix
Version 2.0, beta.01

Archive (.tar) file (4.6 MB file)

 Yale University Rev. 1/97

Contents

Colophon and tools

Colophon

This site was designed by Patrick J. Lynch of Yale University's Center for Advanced Instructional Media, and Sarah Horton of Dartmouth College's Academic Information Resources.

Typefaces used are Palatino (Macintosh) and Times New Roman (Windows95). Illustration labels are set in Geneva, a Macintosh screen font.

Tools

These are the tools we used to create this site. Unless otherwise noted, the software is Macintosh OS.

This site was created primarily with various Macintosh OS computers, and a Dell Dimension 486/66 machine running Windows95.

HTML editing, writing, text editing

- BBEdit 4.0, from Bare Bones Software.

Web browser

- Netscape 3.0 (Mac & Windows95)

Creating image maps

- WebMap 1.0.1

Image editing

- Adobe Photoshop 3.0 & 4.0 (Mac & Windows95)
- Studio8 2.0
- DeBabelizer 1.6.5

Compression

- StuffIt Deluxe

Multimedia

- Adobe Premiere 4.0

Utilities

- Fetch 3.0
- CuteFTP (Windows95)

C/AIM

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About the authors

Photos by William Brawley, Dartmouth College

Patrick Lynch and Sarah Horton began working together in March of 1991 at the Yale University School of Medicine's Center for Advanced Instructional Media (C/AIM). They shared an office the size of a closet and became close friends and colleagues. During that time they authored numerous multimedia titles together, Lynch as Director of C/AIM and Horton as Designer/Programmer. They have co-authored several professional papers and have won many awards for software design, including the 1992 Best-in-Show Award from the Health Sciences Communications Association and a Gold Medal, Silver Medal and Award of Excellence in the international INVISION Multimedia Awards. Lynch continues as Director of C/AIM, and Horton is Multimedia Applications Specialist for Academic Information Resources at Dartmouth College.

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