■ SPECIAL ARTICLE

Medical Information on the Internet

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THE proliferation of inexpensive computers and digital telecommunications technology has spurred the creation of a new model of information dissemination. The Internet is a loosely interconnected web (hence World Wide Web or WWW) of a large number of computers, many of which independently store some quantity of information for public access on demand. Information on every conceivable topic has become nearly instantaneously accessible by telephone or even radio-linked satellite from anywhere in the world. The ease and inexpensiveness of publishing information on the Internet has stimulated a revolution that may, in the future, be seen as significant as the development of the printing press because anyone can now produce instant, global publication.

Public and private professional agencies, commercial interests, universities, and private citizens have all taken enthusiastic advantage of the Internet to publish medical information. The new electronic model of publishing has applied pressure on the medical literature to transform from its traditional peer-reviewed and controlled article-based format to a more free form with variable provenance. Anesthesia professionals using the Internet should develop a strategy for finding trusted information and record some locations within the Internet system that will serve as high-quality repositories.

Although every effort has been made in this review to provide accurate Internet addresses, the dynamic nature of the Internet ensures that some of these addresses will change over time. Internet addresses cited in this review are printed in this monospaced typeface: `www.anesthesiology.org`

To view the contents of a particular web page, one must be connected to the Internet, run a web browser program, and type in the printed address (also known as a URL). Some early browsers may require that "`http://`" be added as a prefix to the address to work.

Hypertext technology is, at the moment, the dominant alluring feature of the Web. The basic concept of hypertext was conceived by Vannevar Bush[1] and was developed by Theodore Nelson.[2,3] Simply put, text is converted to hypertext by annotating or cross-referencing marking key words within the text. These "hot word links" or simply "links" appear as underlined, colored words within the hypertext, which, if activated by the reader using a graphic pointer (mouse) click, expose a new section of text that expands on the original linked words. Reading is thus converted from a sequential or linear process predefined by the author to a reader-controlled nonlinear experience, skipping around or "surfing" as interest or curiosity strikes. The implementation hypertext of the World Wide Web has been extended to include two-way communication between the reader and the publisher. Within the Internet context, hypertext is divided into blocks of text known as web pages. Web pages contain one or sometimes more viewing screens of text with embedded hypertext links connecting the page to web resources elsewhere in the Internet universe, including other pages, pictures, audio and video presentations, and electronic mail (Email) connections.

With funding from the US Department of Defense Advanced Research Projects Agency (ARPA), the Internet developed as a matrix of computers, which could

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◆ This article is accompanied by an Editorial View. Please see: Eisenach JC, Todd MM: The Internet: Where do we want to go tomorrow? ANESTHESIOLOGY 1998; 89(4):817–9.

🌐 This article appears in full text with live hypertext links on the ANESTHESIOLOGY Web Site. Go to the following address, and then scroll down to find the title link for this article. http://www.anesthesiology.org/tocs/v89n5-TOC.cfm

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pass data or military communication around the country, even if part of the matrix was disabled.[4] Through the early 1990s, the Department of Defense and National Science Foundation funded the expansion of the network for military and scientific research purposes. During this time, computer scientists experimented with a variety of applications for networked computers, in addition to the original transfer of data files. These ancillary net services grew in popularity, eclipsing the original research intent, and eventually convinced the government to commercialize the net. The Internet is expanding rapidly, data from the most recent survey (www.nw.com/zone/WWW/report.html) documents more than 37 million computers assigned network addresses and more than 100 million daily users worldwide in the summer of 1998.

When the government relinquished control over access to the Internet, the demographics of Internet publishers shifted dramatically from university-based academics to a population composed predominantly of commercial interests and private citizens. The nearly absolute freedom to publish material on the Internet has led to the current situation in which valuable medical and scientific information must compete for attention with advertising, hucksterism, quackery, and fringe opinion. The extent of frank junk, particularly prurient material was enough to prompt the US Congress to flirt temporarily with the idea of abridging electronic freedom of speech with the now overturned Communications Decency Act. Nevertheless, the Internet remains a valuable resource that can be mined efficiently for medical information, if the user knows where to look.

Sources of Trustworthy Medical Information

Peer-reviewed Literature

The National Library of Medicine (NLM), a branch of the National Institutes of Health (NIH) in the United States has been compiling a bibliographic database of the serial literature of biomedical science of the world since 1966. This database, known as MEDLINE, has citation information and authors' abstracts from approximately 3,900 journals and 10 million papers. MEDLINE is widely considered the premier source of peer-reviewed medical information.[5] Once the domain of librarian-specialists and expensive subscription services, the NLM now provides free access to MEDLINE *via* the Internet.[6] In addition to the continuing availability of the older fee-based systems, the MEDLINE database is available through two different styles of web-based user interfaces. The older

systems, although rendered largely obsolete, still have some adherents, predominantly because of familiarity with the interface or search engine characteristics or because a institutional copy of the database makes access potentially faster.

Internet Grateful Med (igm.nlm.nih.gov) is the free continuation of an old fee-based subscription service. Grateful Med provides a web page data entry form containing many fields with which the user may specify and control the search process (fig. 1). Grateful Med allows searches by subject word, author name, or title word. At the top of the search form a button labeled "Find MeSH/Meta Terms" is the link to the NLM Metathesaurus, a powerful new tool that converts common English language phrases (already entered into a query term field) into precise MeSH search terms. For example, the Metathesaurus will suggest converting "mad cow" into "encephalopathy, bovine spongiform" or "forane" into "isoflurane volatile liquid." Use of the specific language generated by the metathesaurus is highly recommended to ensure that the Grateful Med search engine will find all relevant citations, because it is unforgiving of misspellings. A set of pop-up menus on the Grateful Med page allows the user to specify limit parameters that help to restrict the search results to the most relevant papers. Limit parameters include publication type (*e.g.*, clinical trials, editorials, reviews, letters, and others), gender of study subjects, age groups, and dates and language of publication. If the user appends an asterisk to the beginning of a subject word, the search engine will consider that this subject term must be a major component of the citation, *e.g.*, *remifentanil. After a search has been performed, the resulting citations are listed, eight at a time, in an abbreviated format. This short-format report has the title and author list, the affiliated institution, the journal citation, and a note as to whether an abstract is available. Each citation in the report also has a checkbox that permits the user to select the citation for a more detailed secondary display that includes abstract and MeSH headings. Grateful Med has an option to save detailed search results to the user's local disk. This feature is particularly useful for filling a bibliographic database on the user's local computer to be used later in conjunction with a word processor. Recently, the NLM added a registration feature ("Loansome Doc") that allows users to order full reprints of articles found in a search.

PubMed (www.ncbi.nlm.nih.gov/pubmed/) is a more simple, but still powerful, alternative interface to the MEDLINE database. The entry screen to PubMed furnishes only a single field in which one may enter subject words and authors (fig. 2). The grammar for

Fig. 1 The primary web page for Grateful Med, a free service of the National Library of Medicine. (The large bold numbers on the right were added by the author to label sections of the screen.) Each section of this web page has, when displayed in a web browser, a large italic *I* inside a colored square. When clicked, context-sensitive help will appear. Section 1 contains control buttons to restrict or to initiate a search. Section 2 contains text entry fields (the empty rectangles) and pop-up menus that specify to which database field the search term should be applied. Section 3 contains pop-up menus that can focus the search by several criteria.

basic searching is relaxed compared with Grateful Med, just list the subject words of interest separated by spaces; for example, typing the words "pulmonary vaso-dilation nitric oxide" into the PubMed text field will locate all articles containing these terms as MeSH subjects, title words, abstract words, or author names. When more than one search term is entered in the simple-entry field, the terms are presumed to be ANDed together, meaning all words must be present in a citation to correctly match and be reported. If a multiword phrase is sought, it should be enclosed in quotation marks because the words will otherwise not be required

to be adjacent to match in the search engine. An interactive dictionary of MeSH terms is provided to assist in selecting terms. Author names may be entered as surnames only or with initials. When initials are added, they should be delimited with a comma: "Hamilton WK, anesth*" will find all the publications of W. K. Hamilton that contain a root or a MeSH term that starts with "anesth." The asterisk here serves a different purpose than in Grateful Med. In PubMed, the asterisk is a wild card that allows a match to all subjects and MeSH terms starting with "anesth," including anesthesia, anesthetic, anesthesiologist, and anesthesiology. With experience,

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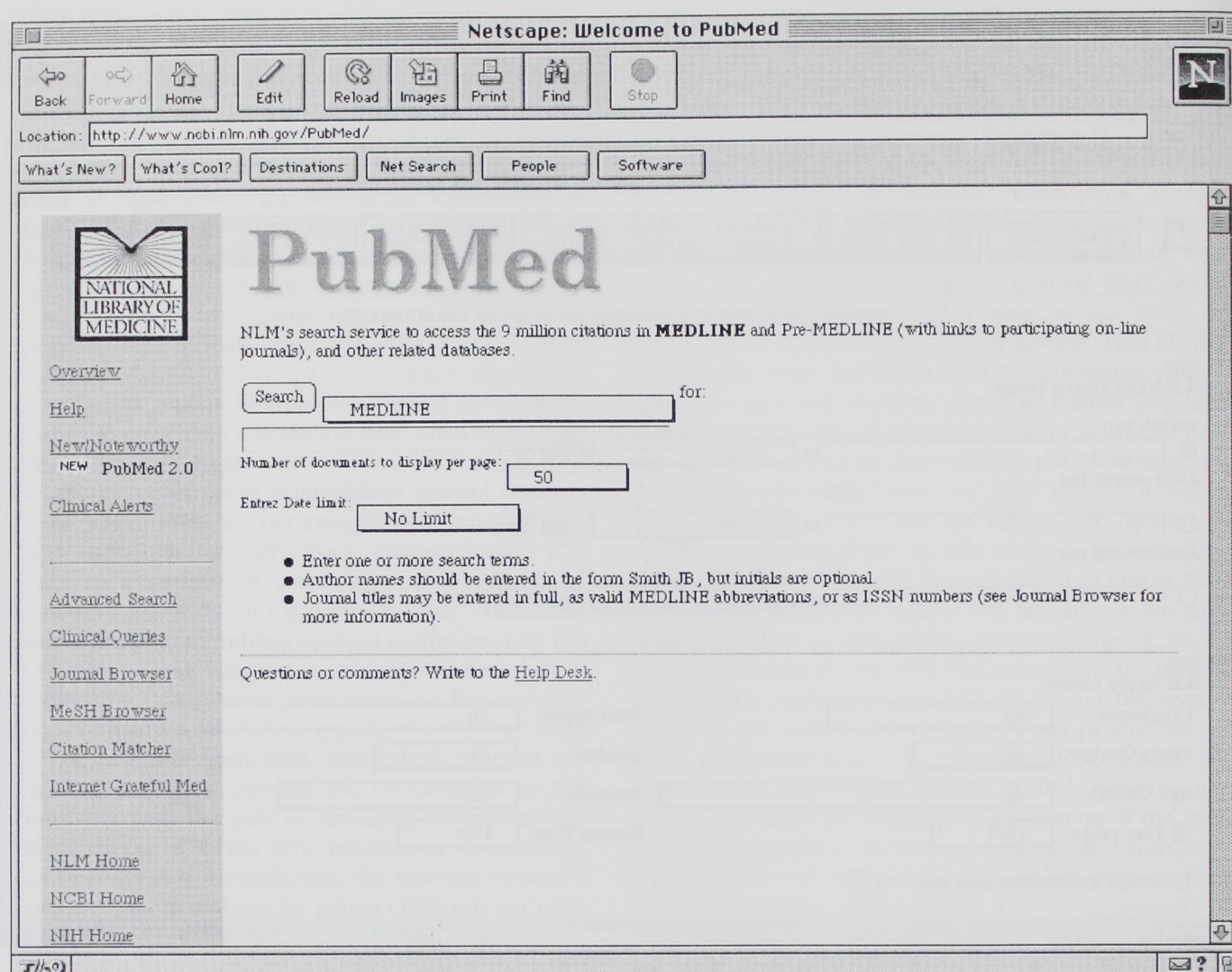Figure caption and body below.

Fig. 2. The primary search control page for PubMed, a simple interface to the MedLine bibliographic database. The right side of the web page contains a single text entry field for search terms. For the simplest type of search, type in the key words followed by the "enter" or "return" on your keyboard, or click on the "search" button on the screen. The left side of the web page is a list of related hypertext links. Of particular interest is the link to Clinical Queries that sets the PubMed search engine to focus on high-impact publications.

PubMed users may use a more sophisticated search grammar that includes Boolean expressions (AND, OR, NOT) and specific search fields (table 1). For example, "clonidine[majr] AND anesthesiology[ta] AND 1996[pdat]" will locate the eight papers that appeared in ANESTHESIOLOGY in 1996 with a major subject of clonidine. Note that although the case of the search terms and fields are not important, the Boolean operator words must be capitalized. The search field descriptors described in table 1 restrict the search to matching only when the search field conditions are met in addition to matching the sought text word or author name. Search field descriptors must be contained in square brackets, as shown. PubMed provides an advanced search page that will prompt the user with pop-up menus for the search field descriptors and Boolean operators. In this advanced mode, a search may be iteratively refined by adjusting the terms and the limits after each search. Alternatively, after a search is performed, clicking the "Details" button will provide the opportunity to see and change the exact search criteria used. A powerful feature of PubMed is the "see Related Articles" link, which appears next to each citation in the short-display list (fig. 3). The process of finding related articles is not a simple

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Table 1. PubMed Database Search Fields*

Field	Abbreviation	Description of Contents
Affiliation	AD, AFFL	The institutional affiliation and address of the primary author
All fields	ALL	covers all searchable PubMed fields
Author name	AU, AUTH	contains the list of authors. The format is the last name, followed by a space and the initial(s), without periods. For example, David J. Lipman would be Lipman DJ. Initials may be omitted when searching. PubMed now automatically truncates on an author's name to account for varying initials, e.g., o'brien j [au] will retrieve o'brien ja, o'brien jb, o'brien jc jr, as well as o'brien j. To turn off this automatic truncation, enclose the author's name in double quotes, e.g., "o'brien j" [au].
E. C. number	RN, ECNO	is a number assigned by the Enzyme Commission to designate a particular enzyme. This field also includes CAS Registry Numbers.
Entrez date	EDAT	The date the paper was initially entered in the PubMed system
Journal title	TA, JOUR	is the name of the journal where the record was published. Journal names are stored in the database in abbreviated form; for instance, the Journal of Biological Chemistry is stored as J Biol Chem. You may also enter the complete journal name or the ISSN number in this field. A Journal Browser is also available to look up the full name, abbreviation, and ISSN number of a journal.
Language	LA, LANG	is the language in which the article was published. Many non-English articles, however, do have English abstracts.
MeSH major topic	MAJR	includes all MeSH terms that are marked as being of major importance to this record by the MEDLINE indexers.
MeSH terms	MH, MESH	includes all of the terms in the Medical Subject Headings, a controlled vocabulary used to index MEDLINE. Each MEDLINE citation is given a group of MeSH terms that relate to the subject of the paper from which it is drawn. Frequently, MeSH terms will have an additional term, called a "subheading," which further defines how the MeSH term relates to the article with which it is associated. This subheading is appended to the MeSH term, *e.g.*, "pneumonia/diagnosis." Searching on the MeSH term (here, pneumonia) will retrieve all of the articles that use that MeSH term, whether they have subheadings or not. Use the subheading terms if you require more specificity than the MeSH term alone allows. Note: MeSH terms searched for using the MeSH or MeSH Major Topic fields are automatically "exploded" by PubMed; that is, all terms that are logical subsets of the term entered are included. For instance, "vision disorders" includes "blindness." MeSH terms found using the "All Fields" search, however, are NOT exploded.
Modification date	MDAT	contains the date that the record was placed into PubMed, in the same format as the Publication Date; see below.
Page number	PAGE	is the number of the first journal page on which the article appears.
Publication date	DP, PDAT	contains the date that the article was published in the format year/month/day, *e.g.*, 1984/10/06. A year alone, (*e.g.*, "1984") will retrieve all articles for that year; a year and month (*e.g.*, "1984/03") will retrieve all for that month. Note that journals vary in the way the date appears, some including only year, some year plus month, some year plus month plus day. PubMed takes the date as it appears in the journal.
Publication type	PT, PTYP	refers to the form of presentation of an article or other work. Examples include review articles, clinical trials, randomized controlled trials, and retracted publications.
Subheading	SH	specifies the MeSH subheading terms.
Substance	NM, SUBS	contains the names of any chemicals associated with this record from the Chemical Abstract Service (CAS) registry and the MEDLINE Name of Substance field.
Text words	TW, WORD	includes all words in the title and abstract, plus individual words from MeSH terms and chemical substance names.
Title words	TI, TITL	includes only those words found in the title of a record.
Volume	VI, VOL	is the number of the journal volume in which this article is published.
Medline ID	UI, MUID	is the MEDLINE unique identifier of a given citation.
PubMed ID	PMID	is the PubMed unique identifier of a given citation.

* Revised from the National Library of Medicine: www.ncbi.nlm.nih.gov/PubMed/pubmedhelp.html#SearchFields.
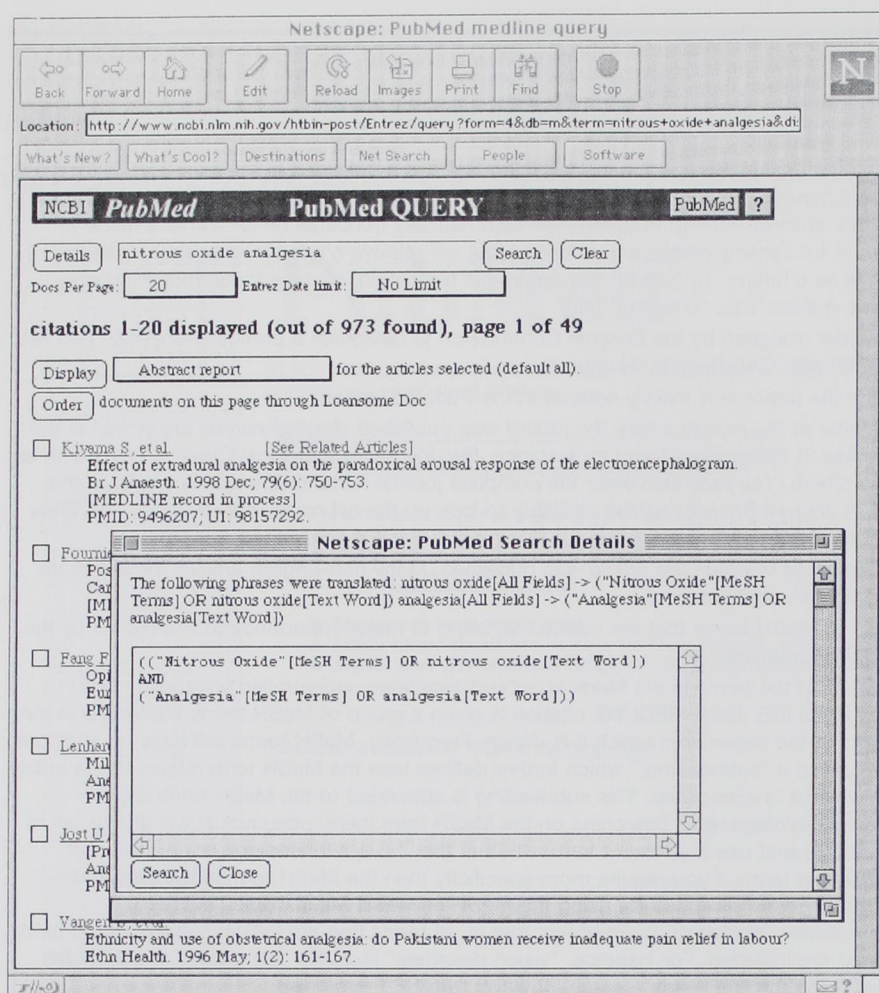
Fig. 3. A search results page. An example of the output of a PubMed search, including the "Search Details" window showing how the PubMed search engine interpreted the query: "nitrous oxide analgesia."

word match, rather it uses a complex algorithm to compare both the text and the MeSH terms of articles when they are first entered into the system to define "neighbors" based on similarity of content. The report list of Related Articles is sorted by degree of similarity.

Another power feature of PubMed is "Clinical Queries," which adds special combinations of key words and search parameters[7] to identify literature of particular interest to clinicians seeking information about therapy, diagnosis, etiology, and prognosis of particular diseases, rather than the exhaustive listing a researcher might need. For example, a Clinical Query for therapy would select only papers marked as randomized controlled trials, having the subheadings of drug therapy or therapeutic use or having the "random" in the title.

As with the Grateful Med interface, PubMed can save the results of a search in various formats for later use; however, if a search produces more citations than will fit on a page, PubMed will only save the selected articles from the current display page. Therefore, it may be useful to set the "number-of-documents-to-display-per-page" option to a value larger than the default of 20. PubMed search reports also provide direct links to the small number of journals (currently less than 100) in which the publisher provides the full text of articles electronically when those articles are matched in a search. Although detailed discussion of search strategies within MEDLINE is beyond the scope of this review, it is worth noting that the quality and content of search results is very sensitive to the approach the user takes to searching. A recent example was provided by two different searches for randomized controlled trials in epilepsy.[8] In this case, one search strategy located 103 articles, and the other strategy located 275 of 308 articles known to be relevant. Similar search requests submitted to both the PubMed and the Grateful Med systems fre-

quently will also lead to (slightly) different results because of differences in the search engine algorithms at the NLM host computer. Search engine foibles related to sensitivity regarding the way authors are listed are also a common reason for failing to find sought papers. For example, authors and journals are often inconsistent in using middle initials. Until recently, PubMed held that initials were optional, yet if they were included in the search, they must be an exact match to the journal. For example, if both an author's initials are specified as part of a search term, those articles published in journals that use only a first initial will not match; conversely, searching for a single initial will ignore those articles in which both are used. PubMed has been modified to automatically perform wild card searches if a single initial is given (see table 1). The long-term solution for users of these databases is the evolution of database search software to automatically translate vocabularies among different disciplines, to intelligently match author names, and to efficiently extract and match core semantic concepts from the archived manuscripts.[9] A database user may then rely on an intelligent search engine to find the right citations, even if they do not include the exact wording sought.

In addition to MEDLINE, the NLM has other databases that contain information for the researcher, the practitioner, and the public. These databases are listed in table 2. The NLM provides a web page (www.nlm.nih.gov/databases/alerts/clinical_alerts.html) listing NIH "Clinical Alerts." These alerts are a public service that reviews the outcomes of major NIH-funded clinical trials and provides notice of results that are thought by the NIH to have the potential for major influence on medical practice. The Food and Drug Administration has a large web site with current drug, device, and regulatory information at www.fda.gov. The Department of Health and Human Services decided in 1997 to participate in web publishing by developing the consumer's guide to health care at www.healthfinder.gov. This site contains links to governmental and private sites containing educational material. Another site of interest is the Medical World Search (www.mwsearch.com), which provides for searches of many thousands of medically oriented sites using the NLM metathesaurus.

Journals

Many traditional peer-reviewed journals have developed electronic outposts on the WWW. These web sites are all in varying states of evolution and, thus, each provides a different set of features. Most journal web sites provide a set

Table 2. National Library of Medicine Databases

Browser Interface	
Grateful Med	PubMed
AIDSLine (HIV-related)	MedLine (medical literature)
AIDSDrugs (HIV-related)	GenBank DNA Sequences
AIDSTrials (HIV-related)	GenBank Protein Sequences
DIRLine (Database Directory)	Biomolecule 3D Structures
HealthSTAR (health planning & assessment)	
HISTLine (history of medicine)	Complete Genomes
HSRProj (research in progress)	
MedLine (medical literature)	
OldMedLine (literature between 1964–5)	
PreMedLine (very recent literature)	
SDILine (most recent month of Medline)	

The genetics databases contain the pooled, cooperative output of many genome-sequencing laboratories.

of contact addresses for the respective editorial offices and instructions for manuscript preparation. Many of these sites provide timely search access to published article abstracts, and a few allow access to the complete text of published articles, including tables and illustrations. Although successful economic models of paperless publishing have yet to be developed, the trend away from paper publishing and third class mailing seems clear. It is also anticipated that electronic publishing will allow the expansion of traditional medical literature to include multimedia. The ANESTHESIOLOGY web site already features several video presentations that enhance published articles. This journal also provides an on-line database of abstracts from the Annual Meetings. Available before the meeting, the database allows one to search for interesting abstracts and to develop a personal schedule for the meeting. Beginning in 1997, abstracts could be submitted electronically and, if accepted, could be retrieved from the web site. Table 3 provides a small sample of the medical journals now on the Web. A more complete, updated list is available at www.yahoo.com/Health/Medicine/journals.

Textbooks and Patient Care Protocols

Many of the major textbooks of anesthesiology (and medicine in general) have electronic counterparts. To date, these works have been commercial and proprietary and only available for sale on a CD-ROM rather than on the Internet. At least two groups of volunteer authors have therefore started to produce web-based texts. The first text, *Global Textbook of Anesthesiol-*

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Table 3. A Sample of Peer-reviewed Journals Available on the Web

Journal	URL	Search Content	Abstracts	Full Text
Anesthesia & Analgesia	anesthesia.ucsf.edu/webdocs/aa/	Y	Y	N
Anesthesiology	www.anesthesiology.org	Y	Y	N
Annals of Internal Medicine	www.acponline.org/journals/annals/annaltoc.htm	Y	Y	P
Chest	journals.chestnet.org/chest/first.html	Y	Y	N
Journal of the American College of Cardiology	www-east.elsevier.com/jac/	Y	Y	P
Journal of the American Medical Association	www.ama-assn.org/public/journals/jama/jamahome.htm	Y	Y	N
Nature Medicine	medicine.nature.com	Y	Y	N
New England Journal of Medicine	www.nejm.org	Y	Y	N
Science	www.sciencemag.org	Y	Y	Y

Y = yes; N = no; P = paid subscription.

ogy (`gasnet.med.yale.edu/gta`) has a structure similar to traditional texts with major sections and chapters. Currently, the 28 available chapters tend to be narrowly focused and together discuss perhaps 5–10% of the field of anesthesiology (compared with the table of contents of a text such as that of Miller[10] or Barash[11]). The reader should note that the contributions have not been reviewed or edited. The second effort, based in Australia, is the *Virtual Anaesthesia Textbook* (`www.usyd.edu.au/su/anaes/VAT/VAT.html`). This site is an organized compendium of preexisting anesthesia-related web pages. Volunteer chapter organizers seek web pages containing appropriate key words and list them within the framework of a "chapter." Although this is certainly an interesting experiment in electronic collaboration, the results predictably are uneven. Some of the linked pages are of high quality, others are of marginal quality or relevance, and the thematic coverage is spotty, subject to the organizers' ability to track down what other people have written.

Some of the pages linked by the *Virtual Anaesthesia Textbook* were written as teaching handouts. A small number of academic departments, professional societies, and individuals have placed resident-oriented teaching materials on the Internet. These include electronic versions of lecture notes and local protocols for the anesthetic conduct of certain types of cases. These pages often provide useful insight into case management and serve as a reminder of the variability in approach across institutions. It is essential to recall, however, that this type of web page is not subject to rigorous review. Therefore, suggestions regarding pharmacology, especially off-label usage of drugs, must be considered to be only advisory. The Internet also has been proposed as a

means of distribution of research protocols for multicenter trials.[12] A few examples of patient care protocols published on the Internet are listed in table 4.

Grants and Funding Information

In the current competitive-funding environment, timely access to the current NIH Requests for Proposals (RFP) and other Institute bulletins and offerings can be quite useful. The NIH provides several means by which investigators may stay abreast of funding opportunities. The NIH Guide is available on the WWW (`www.nih.gov/grants/guide/index.html`). Downloadable versions of the NIH application forms also are available at `www.nih.gov/grants/forms.htm`. Each Institute maintains its own web site as well. The RAMS-FIE company offers a free Email notification system (FEDIX Opportunity Alert), which allows subscribers to submit fields of interest to a database that will then notify them of relevant federal funding opportunities as they are announced. Subscriptions are available at `www.rams-fie.com/opportunity.htm`.

The NIH maintains a database (CRISP) of funded research projects that may be searched *via* the Web. The CRISP system uses a relatively older Internet protocol known as "Gopher," which limits the user to a simple text-list interface. Nonetheless, CRISP contains project abstracts and investigator and institutional information.[13] The CRISP search engine may be accessed at `www.nih.gov/grants/award/gophercrisp.htm`. Beginning in March of 1998, the American Association for the Advancement of Science and the Howard Hughes Medical Institute formed a collaborative web site at `www.grantsnet.org` that allows access to a large database of biomedical funding agencies. Anesthesia-spe-

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Table 4. Resident Teaching Materials and Patient Care Protocols on the Web

Title	Author	URL
Redbook (Resident Handbook)	University of Basel	www.medana.unibas.ch/eng/amnesix1/amnesix.htm
Electronic Training Text	University of Miami	umdas.med.miami.edu/ett/etthome.html
Educational Research Lab	Cleveland Clinic Foundation	www.anes.ccf.org/pilot/
Electronic Case Conferences	Penn State University	www.anes.hmc.psu.edu/caseconferencefolder/caseconferencetoc.html
Neuroanesthesia Basics	New York University	mcns10.med.nyu.edu/research/basicneuro.html
Anesthesia for the pregnant patient	University of Chicago	dacc.bsd.uchicago.edu/library/manuals/obstetric/obanesthesia.html
Didactic Materials	University of California, San Francisco	anesthesia.ucsf.edu/anesthweb/didactics/didacthome.html

cific funding information is available at a few sites listed in table 5, including the Foundation for Anesthesia Education and Research (FAER) and the Anesthesia Patient Safety Foundation (APSF).

Politics and News

The influence of political and social forces on the practice of medicine has never been greater. Changing social policy regarding access to health care and the ascendancy of competitive health maintenance organizations with the attendant economic consequences constantly buffet the practitioner. Up-to-date information is therefore as important in this area as it is in the scientific arena.

Table 5. Anesthesia-related Subspecialty Web Sites

Organization	URL
American Society of Anesthesiologists	www.asahq.org
American Society of Critical Care Anesthesiologists	gasnet.med.yale.edu/ascca
American Society of Regional Anesthesia	www.asra.com
Anesthesia Patient Safety Foundation	apsf.med.yale.edu
Foundation for Anesthesia Education and Research	www.asahq.org/faer/
Society for Ambulatory Anesthesia	www.samba.org
Society for Cardiovascular Anesthesia	dacc.uchicago.edu/sca
Society for Neuroanesthesia & Critical Care	anesthesia.ucsf.edu/snaccweb/
Society for Obstetric Anesthesia and Perinatology	www.anes.ccf.org/soap/index.htm
Society for Pediatric Anesthesia	www.uams.edu/spa/spa.htm
Society for Technology in Anesthesia	gasnet.med.yale.edu/wsta/sta/

Professional organizations, including the American Society of Anesthesiologists (www.asahq.org) and the American Medical Association (www.ama-assn.org), have web sites that offer practice news and commentary, in addition to membership-oriented services and educational features for the general public. The web site of the American Society of Anesthesiologists also maintains a library of downloadable practice guidelines that have been reviewed and approved by the organization. Anesthesia-related subspecialty organizations have also developed a presence on the Internet (table 5). These organizations provide newsletters, information regarding scientific and professional meetings, and some access to subspecialty journals. For those with an interest in the latest alterations in regulations, reimbursement, and enforcement issues, the Department of Health and Human Services, Health Care Financing Administration maintains a web site at www.hcfa.gov. Although the nature of industry-sponsored web sites is one of product promotion, many companies also provide useful educational resources. Several pharmaceutical companies have sponsored the development of news and information sites relevant to anesthesia practice.

General news is available from many Internet sources. Daily newspapers and weekly magazines are available at web sites or *via* subscription Email. Major news organizations, such as the New York Times or CNN, often have timely coverage of significant medical stories. The Reuters news agency provides current health-related news features at www.reutershealth.com. A current listing of general news sources may be obtained from a web directory, such as Yahoo (www.yahoo.com/news).

Departments of Anesthesia

Many academic and private departments of anesthesia have web sites. These sites provide information about the faculty, the residency program if present, and, in some cases, descriptions of special clinical services for prospec-

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tive patients. Up-to-date, if incomplete, lists of anesthesia department web pages can be found at www.yahoo.com/Health/Medicine/Anesthesiology/Institutes/ or www.asahq.org/anes_links.html.

Index Sites and Catalogs

Although to some extent all web sites provide cross-reference links to other web sites, there are a few sites that attempt to catalog important anesthesia-related sites. Considering that at the start of 1998, there were more than 13,000 web pages that at least contained the word anesthesia, a complete catalog would be an immense task, requiring manual review of all pages. Catalog sites therefore tend to rely on notification by individual web publishers. Examples of large catalog sites include "www.invivo.net/bg/accueil2.html" and "www.eur.nl/cgi-bin/accri.pl."

Discussion Groups

A popular means of professional communication on the Internet is known as a discussion group: groups of interested people send their Email addresses to a central party known as a host or list-server, creating a list of recipients. A member of that list may then send an Email message to the central host, which in turn rebroadcasts the message to all members on the list. The message traffic on these lists may be rare or may contain dozens of messages per day. Many active discussion groups provide a digest service as an alternative to receiving a multitude of individual messages. The content of the messages ranges from seeking and rendering clinical advice, discussion of cases, or even frank commercial "spam." Some list-servers are "moderated," meaning that the person owning the list reviews each incoming message for appropriateness before rebroadcasting. Digests collect all the incoming traffic for a period of time, combining the messages into a single broadcast message. The largest anesthesia-related discussion group is GASNet (gasnet.med.yale.edu/maillist/). A list of more than 50 anesthesia-related groups with contact addresses can be obtained at www.eur.nl/fgg/anest/wright/wgt4.html.

An Internet service known as USENET provides a different variant of the discussion group. Instead of using Email to communicate with a fixed list of subscribers, USENET follows a public bulletin board model. USENET provides for topical bulletin boards, also known as newsgroups, to which anyone may read or post messages. Currently, USENET contains over 30,000 separate newsgroups, although no publicly accessible groups relate specifically to the practice of anesthesia or critical care. Newsgroups are named to place themselves within a subject hierarchy. For example, "comp.sys.mac.digest" is a newsgroup within the root group concerning computers (comp) related to Macintosh computers (.sys.mac), which specifically contains summaries of news, commentaries, and new file postings (.digest). Another example is "rec.auto.bmw," which is a newsgroup for which hobbyists and enthusiasts (rec = recreation) discuss the minutiae of BMW automobiles. Topics of general medical interest may be found within the sci.med (medical sciences) hierarchy (e.g., sci.med, sci.med.cardiology, sci.med.pharmacy, sci.med.informatics, and others). Basic neuroscience also is discussed in the bionet.neurosci group.

On-line Journals

Early in the genesis of the Internet, the ability to instantly disseminate information proved tempting to investigators eager to get their message out. The physical scientists were first, creating in the 1980s an on-line archive of preprint manuscripts, followed by an on-line peer review system for traditional and purely electronic publications. Recently, there has been an effort to create a similar venue for the field of anesthesiology. A purely electronic, peer-reviewed journal, the *Internet Journal of Anesthesiology* now appears at www.ispub.com/journals/ija.htm. This journal provides a venue for publications that include multimedia (video, sound, and color pictures) or interactive features. Another electronic publication is the *Educational Synopses in Anesthesiology* (ESIA) at grocho.med.yale.edu/esia that provides topical reviews and reports.

General Information

With more than 100 million web pages and millions more file transfer protocols (FTP) and gopher sites and USENET messages per week, some information is available about almost any conceivable topic. A hallmark of this collection of information is that there is absolutely no central control or indexing; finding relevant information is almost always an uncertain venture. Because of the great popularity of the Web, more than a few commercial ventures have arisen that attempt to index the Internet; most provide free searches to the public in exchange for viewing advertising banners. Each of these services has different characteristics: some are presented as primarily search engines, e.g., Alta-Vista and Open Text, whereas others, such as Excite, Infoseek, Lycos, and Yahoo, are organized as hierarchical directories, although they may have some search capability. Search

engines usually will locate more web pages than directories, but the directory results usually will be more relevant. Some search engines simply identify and index words that appear on the page (*e.g.*, Alta-Vista), others attempt, *via* simple computer algorithms, to identify concepts within the text for higher level indexing (*e.g.*, Excite). Most of these services search the newsgroups of USENET and the Web. The Alta-Vista search engine catalogs more than 100 million web pages in a database containing more than 200 gigabytes of text. Other services range from nearly that comprehensive to lists that contain only several hundred thousand web pages that have been selected for content or, in some cases, commercial consideration. Web indexes are dynamic, with new entries constantly fed into the databases by the page authors or by so-called automated web spiders. Spiders are software programs that aggressively map the WWW by reading all the text and the links on a page then following up on the found links in an iterative process that tries to find all available web pages. Because the Web is so large, a complete traversal by a fast spider system can take weeks. Because of this time delay, some fraction of the web sites located by a search or in a directory will no longer be available at the listed uniform resource locator (URL, see glossary). Attempts at access lead to an error message (the infamous "404 error: File not found"). In many cases, a URL is rendered obsolete by a rearrangement of files in the disk of the server, rather than by actual deletion. There is no harm in such cases for the web surfer to remove the file directory information in the URL, leaving just the domain (host) name. Reading the top web page of the host server will often provide a path, or at least a clue, to the whereabouts of the missing pages. Another complication in locating Web-based information is that many web pages are now dynamically generated. This means that instead of existing as a static file, many web pages are created by the Web server or an associated database engine uniquely for each download request. Such pages cannot be captured adequately and cataloged by a spider program. When using a search or directory service for medical information, one must remember that random web page citations resulting from a search may have a random probability of containing accurate information. A useful strategy is to first pick a single directory service, such as Yahoo (`www.yahoo.com`), and become familiar with its search grammar and capabilities. If a search there is

unavailing, then move to a large index site, such as Alta-Vista (`altavista.digital.com`), where again, knowing the search grammar will allow the user to perform a highly selective search. Several organizations provide "meta-searching" by providing a single entry form that dispatches the search request to several directory and index sites simultaneously. Examples of meta-search sites may be found at `www.metacrawler.com`. or `www.designlab.ukans.edu/profusion`.

The power and failing of the Internet is that it provides an accessible medium in which true freedom of the press is the rule. Medical professionals and healthcare consumers may enjoy the adventure of surfing the Web as much as anyone, but when seeking reliable medical information, it is prudent to exercise judgment and to rely on sources of known provenance.

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Appendix: Current Computer Network Services and Protocols

Each type of computer network service makes use of a different computer protocol. These protocols set certain limits regarding how information is available using that service.

Electronic Mail

Electronic mail (Email) is a network service designed to transmit a message privately from one person to another. The transmission process moves the message from one computer host to another until the message arrives at the destination computer, from which the recipient will retrieve the message. Note that the transmission process is not secure, and messages may be intercepted and read with little effort at any point along the transmission route, unless the message is encrypted. Email may include binary data, such as executable programs or formatted word processing documents, and simple text. The binary data is translated into a form of ASCII text using UUEncode or MIME for transmission across the network, but this translation process is usually automatic and invisible to both the sender and the receiver.

File Transfer Protocol

A file transfer protocol (FTP) requires FTP-server software running on a central or server computer and client software (that may be built-in to a web browser) on the user's computer. When a document is transmitted *via* FTP, it is moved directly from the host hard disk to the client hard disk without being displayed on the screen. Very long documents or raw data files usually are transferred by FTP. Web spiders do not have access to the contents of FTP documents; therefore, standard web directories systems can only index files at an FTP server site by file name, if they are seen at all. The FTP services require that the client or user log-in to the host computer. Those FTP sites that allow public access commonly grant that access to users entering "name anonymous" or "guest" as the log-in name with a password of "guest" or the user's actual Email address.

Gopher

Gopher is a protocol similar to FTP, except that it does not require the user to log-in to access the files being served. Gopher technology was antecedent to WWW/HTML and has nearly been replaced by web sites. Web spiders do not index gopher sites, instead there is a separate system that uses software known as ARCHIE, JUGHEAD, or VERONICA (www.yahoo.com/computers_and_internet/internet/gopher/searching/). Gopher, similar to FTP, requires only a text-based user interface, which was the common mode of Internet access before inexpensive personal computers and graphical web browser software. A new Gopher-to-Web search site can be found at www.nedesign.com/sites/.

USENET

SENET is a distributed message-passing system. The actual messaging protocol is known as Network News Transfer Protocol (NNTP). NNTP uses the "pouring water" technique to pass messages, which implies that a message "poured" into a host spreads horizontally through the network to other nearby computers until all NNTP servers get the message. At a later time, individual USENET users throughout the world may retrieve the message from a local server. At the end of 1997, well-connected NNTP servers handled an average of more than 600,000 messages per day (and rejected roughly $\frac{1}{3}$ as spam or unsolicited, commercial junk mail messages).

Hypertext Transfer Protocol

Hypertext Transfer Protocol (HTTP) is the basic communication protocol used by the WWW. HTTP provides a means by which remote clients (web browsers) may request downloads of files without logging in to the host. Most of the time, the requested files are web pages, but they need not be. Web page files are written in HyperText Markup Language (HTML). HTML files are ASCII text that declares the actual readable text and its associated formatting. HTML files also contain URLs for whatever embedded objects may be in the page, *i.e.*, pictures, JAVA applets, hypertext links, and others. There are many software products that allow creation of HTML web pages in a process akin to word processing. A person may then "publish" these pages on the WWW by transferring the files to their Internet service provider's host computer disk.

Glossary

For a larger glossary, see www.matisse.net/files/glossary.html).

Address: Every computer on the Internet is assigned a unique numerical Internet protocol number (IP) address that must be used to direct communications. Most computers also have an alphabetic (domain) name that is easier to remember.

Applet: A small JAVA program embedded within a web page.

ASCII: American Standard Code for Information Interchange. The numerical code by which computers represent alphabetic letters, numbers, and symbols.

Bandwidth: The speed rating of a communications link. Usually measured in bits/s where an ASCII character is eight bits and a full page of text is approximately 16,000 bits. Standard modems provide a bandwidth of 28,800 bits/s.

Domain Name: An alphabet name (*e.g.*, human-friendly) that is assigned to an IP number address. The Internet provides a way to automatically convert between IP numbers and domain names.

FAQ: Frequently Asked Questions. A list of common questions and answers. Usually an unreviewed volunteer effort.

FTP: File Transfer Protocol.

HTTP: HyperText Transfer Protocol.

HTML: HyperText Markup Language.

IP: Internet Protocol Number. A numerical address unique to each computer on the Internet. An IP address consists of four 8-bit numbers separated by periods (*e.g.*, 128.218.173.143).

JAVA: A computer programming language designed to create programs downloaded as part of a web page and executed on the user's computer instead of the remote web server.

MeSH: Medical Subject Heading. The controlled, hierarchical vocabulary used to index MEDLINE.

Modem Modulator–Demodulator: A device that converts binary com-

puter data into sound signals for transmission across a telephone network.

MIME: Multipurpose Internet Mail Extensions. A protocol to convert binary data to ASCII so that it may be sent by Email on the Internet.

NNTP: Network News Transfer Protocol.

POP3: Post Office Protocol (Version 3). A popular Internet Email protocol.

RFC: A Request for Comment document. The documents are the actual technical description and specifications for Internet protocols. They are published by a group known as the Internet Engineering Task Force (IETF). RFCs may be read *via* the Internet at `ds.internic.net/ds/dspglintdoc.html`.

Spam: Unsolicited electronic junk mail.

TCP: Transmission Control Protocol. The underlying data transmission schemes that move data across the Internet.

URL: Uniform Resource Locator. An expanded electronic address that defines the location of information on the World Wide Web. Each URL contains a protocol, an IP numerical address (or its equivalent domain name), and a file address within the remote computer. The protocol is separated from the actual IP address by a colon and two forward slashes (*e.g.*, `http://www.anesthesiology.org/guide.html`), and the file path and name "guide.html" follows the protocol and host address using a single forward slash separator.

UUEncode: Unix-to-Unix Encoding. A protocol to convert binary files into a format by which they may be transferred *via* Email or USENET.