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NLM Gateway;
A Report to the Board of Scientific Counselors

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Executive Summary

The NLM Gateway was designed to provide simultaneous access to results from a number of NLM's resources. Users make a single query at the Gateway Web interface. The intended audience consists of interested persons who are not quite sure what they will find among NLM's considerable array of databases and Web interfaces, or where to look. One of the goals is to bring before the users potentially useful results from databases such as DIRLINE that are far less well known than MEDLINE.

The original NLM Gateway was released to the public in October 2000. We present in this manuscript a comprehensively redesigned NLM Gateway that went live in parallel with the old system April 4, 2005. The original Gateway will be retired May 2, 2005.

Navigation in the new NLM Gateway is quick and clean. One-click access to results from each of 15 NLM information resources is available. Formerly complex functions have been made simpler and more accessible. The look and feel are more straightforward and understandable than in the predecessor system.

Where possible, important functions of the target databases (for instance, the Related Articles function in MEDLINE/PubMed) are made available directly from the Gateway interface. Results are presented in a consistent manner, within the Gateway when appropriate, and in a new window on the target site itself when necessary. Results can be emailed or downloaded. The basic search is simple and intuitive: enter a term or terms in the box and press Enter.

Multiple custom settings are available for users who wish more control over the searching process and the results display. For some collections, the user can specify individual fields for display from the underlying records. PubMed Central and the LinkOut function from MEDLINE/PubMed are present. Document delivery through NLM's Loansome Doc service is an option for results from the collections for which delivery is available.

A term finder function uses MeSH and the UMLS Metathesaurus to help users find good search terms. Qualifiers can be added to terms that are MeSH headings. The NLM Gateway interface incorporates phrase detection and spell checker functions.

The new NLM Gateway offers a rich foundation for exploration of issues in federated searching, results display from multiple target systems, user profiles and clusters of databases, and use of the UMLS Metathesaurus to help users find good search terms.

1.0 Background

The National Library of Medicine (NLM) began offering information online in the 1960s. Since then, millions upon millions of users worldwide have found information they needed in NLM's databases. In the early years, users often serving as intermediaries to those seeking information had to take one-week or two-week courses to learn the command language necessary for effective searching. This changed in the 1980s, when the program called Grateful Med was developed to facilitate end user searching. Programs like Grateful Med were the vanguard of a revolution: users who were not themselves experts were now able to find useful information where they needed it, when they needed it.

The 1990s saw the advent of the World Wide Web and of no-cost searching in the databases of the National Library of Medicine. This had an even stronger effect. Usage skyrocketed, from 7-10 million searches a year, to well over two million searches a day across all NLM databases. Many different types of users were now accessing NLM information online: trained medical librarians, physicians and other health care providers, biomedical researchers and students, and increasingly, the lay public end user. Hugely increased usage, coupled with an increasingly varied user population, creates new opportunities for NLM systems to provide access points designed for the new generation of information seekers.

2.0 Project Objectives

The National Library of Medicine offers an increasing number of Internet-based information resources, each with its own Web address and its own user interface. We believe an intelligent gateway system may help some of NLM's users by letting them initiate searches in multiple retrieval systems from one interface at one address. The NLM Gateway is such a system. An important point to note is that the individual systems still have their own interfaces, for those who do know where to look and who wish to do focused searches in a single place.

The target audience for the new system is the Internet user who comes to NLM not knowing exactly what is here or how best to search for it. The user audience includes a wide variety of persons with differing training, backgrounds and experience. New NLM systems draw in users with diverse information needs. The very successful MedlinePlus site for consumer health information, built for the public end user, may well lead users to wonder "So what else is there?" Other widely publicized sites such as ClinicalTrials.gov and the highly specialized Toxicology Data Network (TOXNET) on the Web may further increase the number of first-time users accessing NLM information. There is another category of users as well: machines. Sometimes other programs need Application Program Interfaces (APIs) to access our information.

The goals of the Gateway system are to

- Provide "first-stop shopping" for an increasing number of NLM information resources,
- Help lead users to information they might not have known was present,
- Offer citations, full text, images, video, and audio
- Ultimately, offer user profiles to guide searches in clusters of databases.

3.0 Project Significance

The Gateway project directly addresses the problem of users who may be unsure where to look and who don't want to learn a dozen new interfaces. It provides a single address with a single look and feel. It accepts the user's query, reformulates it, and sends it automatically to multiple retrieval systems having different characteristics but potentially useful results. In the original production version, results from the target systems were presented in categories (e.g., journal citations; books, serials and audiovisuals; consumer health; meeting abstracts; other collections) rather than by database. Access to multiple collections within a single category of results was offered when the organization of the information made this useful. The new NLM Gateway returns to the more familiar viewing of results by information resource searched.

We expect that users will come to the Gateway for an overview scan of NLM's resources. Those who immediately find what they need will be pleased. If they note that one resource such as Medline/PubMed or MedlinePlus has information they'd like to know more about, they can go straight to that resource for a focused search using its native interface. Direct links to other major NLM resources are provided on the Gateway's search screen. This combination of a single point of access for an overview scan coupled with focused searches for a second phase of inquiry should help improve user access to information offered at NLM's increasingly comprehensive series of Web sites.

4.0 Status Report

The original NLM Gateway was released in October 2000. It was significantly enhanced over the next four years, with access added to a number of additional databases (see Resources Accessed by the Gateway, below). Tens of thousands of abstracts were added to the Meeting Abstracts resource. Many functions were added or improved based on usability testing, user feedback, and suggestions from colleagues and from this Board. Further detail will be found in Methods and Procedures.

A comprehensively redesigned NLM Gateway was released April 4, 2005, running in parallel with the original system for a four-week period. It will be live on its own when the original system is retired May 2, 2005. The new NLM Gateway is a significant departure from the original, both in its organization and in its look and feel. It is cleaner, simpler, and easier to navigate. Seldom is any resource more than one click away. The new system runs on Dell/Intel servers using the Linux operating system, making it possible to upgrade capacity at much lower cost than with the former Sun/Solaris servers. The software architecture involved in the infrastructure redesign was created with the needs of a forthcoming NLM bioethics site carefully considered.

As with the original, the New Gateway is a meta-searching system, mapping user queries to appropriate search commands for multiple backend systems and issuing simultaneous searches in 15 databases. Hit counts for all 15 databases are shown on one results summary page. With one click, the user can display results from any of the 15 resources. While looking at those results, the user can with one click move to any of the other 14 result sets or to the UMLS Metathesaurus.

Significant infrastructure changes were made to facilitate this direct access to results from specific databases rather than the former categories of results: journal citations,

books/serials/AVs, consumer health, meeting abstracts, and “other collections”. We hypothesize that many users of the original Gateway did not clearly understand that results from more than a dozen resources were available; they viewed only the first set of results shown. The new system makes the additional resources far more accessible.

4.1 Previous Board Review and Recommendations

This project was reviewed by the Board of Scientific Counselors in May 2000. Several helpful recommendations were made at that time. Many have been acted upon and implemented. The recommendations are printed in italics below.

Establish a mechanism to provide a predictable time and place for ongoing discussion of research possibilities associated with the Gateway project. Incorporated frequently into weekly Gateway team meetings, with discussion of user behavior, browser usage, interface factors, and statistical reports derived from action logs.

Expand current principles of organization, searching, and presentation beyond format and subject matter to include user perspectives and scenarios of usage. Examples might include expanding preference options. Done to some extent, with preference options expanded and made easier to find. Enabling users to declare their professional background or subject focus not yet done, but still a good idea.

Give users options of maintaining preference profiles in a manner that does not require them to log in. Done. It was a good recommendation: users asked for it as well; we implemented it.

Provide links to glossaries for instant definitions of terms. Done. Users unsure of terms can find definitions in the UMLS Metathesaurus with the Term Finder and can find much more information almost instantly in the MedlinePlus Medical Encyclopedia, Health Topics, and Health Tutorials.

Consider “current awareness” e-mail alerts or standing search profiles for some sources. Bookmark this Search function allows creation of standing search profiles the user can return to from his or her own Favorites or Bookmarks list. E-mail alerts not done, but would be possible.

Automatically chain bad results (e.g., null retrieval) to available help functions. Fruitful area for future functional assistance; not yet done.

Monitor evolution of the look and feel of interfaces to major Internet search engines. Emphatically done. Tabbed user interface, cleaner look, more understandable presentation of results, page layout, quicker navigation among functions all in the redesigned NLM Gateway with careful attention to what the major search engines have done.

Remove inconsistencies in query formatting requirements among NLM’s own systems (e.g., phrase detection to avoid need for quotes around multiword terms). Specific example given is done. Both old and new Gateways use a phrase detection system written by a team member. They also use the Gspell spell checker used in several other NLM systems.

Develop a framework for monitoring sources of performance bottlenecks. System monitoring done. A “heartbeat” system of many scripts checks various aspects of the Gateway’s performance and sends e-mail notifications to the systems group when problems are detected and again when normal function resumes. Network bottlenecks are monitored by the LHCBC-wide network support group.

User-focused design might extend to changing the priorities and order by which documents are indexed. A good observation. Not in scope for the Gateway development team, but already done by NLM. Indexing priority is given to the most important journals and other resources. Highest-priority ones are indexed almost immediately.

5.0 Methods and Procedures

5.1 Resources Accessed by the Gateway

The NLM Gateway accepts the user’s query and translates it as appropriate for different retrieval systems. Specific examples will be shown later. The current version of the NLM Gateway issues simultaneous searches in

- MEDLINE (over 15 million journal article citations 1950-present, in PubMed using the Entrez API; includes access to LinkOut and PubMed Central)
- NLM Catalog (over 1,200,000 books, monographs, serial titles, audiovisuals, other cataloged information; searched in Entrez using the Entrez API)
- TOXLINE Special (a subset of non-Medline bibliographic records in TOXLINE on the effects of drugs and other chemicals, searched using the TOXNET API)
- Meeting Abstracts (over 88,000 HIV/AIDS abstracts, 9,900 Health Services Research abstracts, 900 Space Life Sciences abstracts, all searched in the Verity retrieval system component of the Gateway)
- MedlinePlus Health Topics (over 700 health topics, searched using the MedlinePlus API with hot links to MedlinePlus itself after search)
- MedlinePlus Drug Information (for over 9,000 drugs, searched as with Health Topics)
- MedlinePlus Medical Encyclopedia (over 4,000 articles on diseases, tests, symptoms, injuries and surgeries, searched as with Health Topics)
- MedlinePlus Current Health News (late-breaking stories about medicine and health, searched as with Health Topics)
- MedlinePlus Health Tutorials (easily understood animated graphics and sound to explain conditions and procedures, searched as with Health Topics)
- ClinicalTrials.gov (over 12,700 clinical trials, searched using the ClinicalTrials.gov API)
- DIRLINE (over 9,000 records on health organizations, searched using the DIRLINE API)
- Genetics Home Reference (consumer information about genetics conditions, searched using the GHR API)
- HSRProj databank (over 6,200 Health Services Research Project records, searched in Verity)
- OMIM (Online Mendelian Inheritance in Man, catalog of over 15,000 human genes and genetic disorders, searched using the Entrez API)
- HSDB (Hazardous Substances Data Bank covering over 4,700 hazardous substances, searched using the TOXNET API)

- UMLS Metathesaurus (3,000,000 names for 1,060,000 concepts from 100 vocabularies in 15 languages, searched using custom Gateway code)
- Document delivery (through NLM's Loansome Doc facility).

5.2 Gateway Architecture and Transaction Flow

The Gateway is fully object oriented, written primarily in Java and using the CORBA (Common Object Request Broker Architecture) distributed object computing infrastructure from Visibroker. The current design deliberately does not use “cookies” and can run without JavaScript, since both are sometimes banned in institutional settings for security reasons. If JavaScript is enabled, the Gateway takes advantage of it to enhance the user's experience. An example is allowing the user to press the Enter key to initiate a search rather than having to click on the Search button on the screen.

Users can use the Limits/Settings function to adapt important aspects of the interface to their needs. As an example, under the Settings function the user can specify which record elements are to be presented in the brief and expanded displays. Users can set temporary limits and settings for the current session without having to log in, or can log in to store them as longer-term settings. A “locker” is used to store selected results the user wishes to keep across sessions. Use of the locker requires a login. Users can order documents and can email results to themselves or to colleagues.

Where appropriate, internal data interchange is done in XML. External data interchange is XML-preferred, but output is offered in XML, HTML and ASCII text. There are Application Program Interfaces (APIs) to major Gateway functions to make them accessible to other programs. In particular, the Metathesaurus browser component of the new system will provide standalone functions accessible to other programs. The commercial Resonate system provides virtual IP services that allow load sharing and failover among multiple machines. MySQL is used for the database of user IDs and passwords that allows users to log in and be matched with their settings and their lockers. MySQL is also used to maintain system state and session information for each active user. If a server goes down for some reason, the session can continue with mirrored state information from the redundant MySQL servers. A Gateway system architecture diagram is shown in Figure 1.

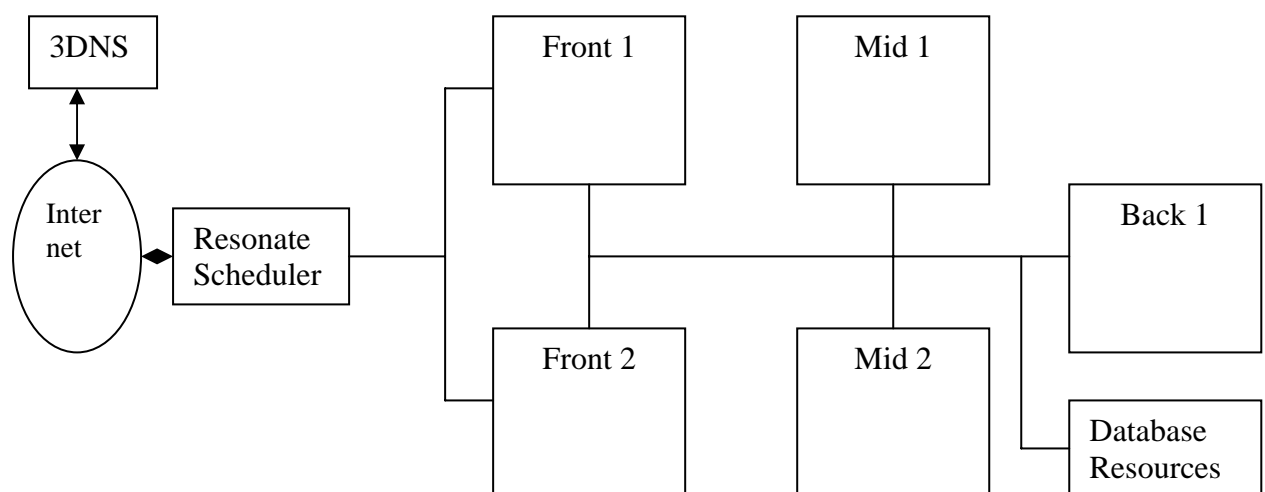


Figure 1. NLM Gateway System Architecture

The Gateway server farm is replicated in two areas: in the primary machine room on site at NLM, and at the NIH Consolidated Collocation Site in northern Virginia. Six servers are present at each site. The commercial 3DNS system is used for load balancing between the two sites. A Resonate scheduler, as noted above, handles load sharing and failover to machines within each site.

The redundant Front Layer machines run the Apache Web servers, the Command Broker Java servlet, the Security Manager ORB, the Preference Manager ORB, and the Alarm Panel ORB. The ORBS will be discussed later in this section. The Mid machines run the Application Layer: the User Interface ORB, the Document Object Model ORB, and the Data Source Broker ORBs. The Back machine (its redundant replicant is at the Collocation Site) runs the mySQL and Verity databases. The mySQL system is used for UserIDs and passwords, user lockers, user settings, and session information including state. The Verity system is used for the Meeting Abstracts collections and the HSRPROJ resource.

A Gateway functional diagram in Figure 2 helps illustrate the relationships among system modules.

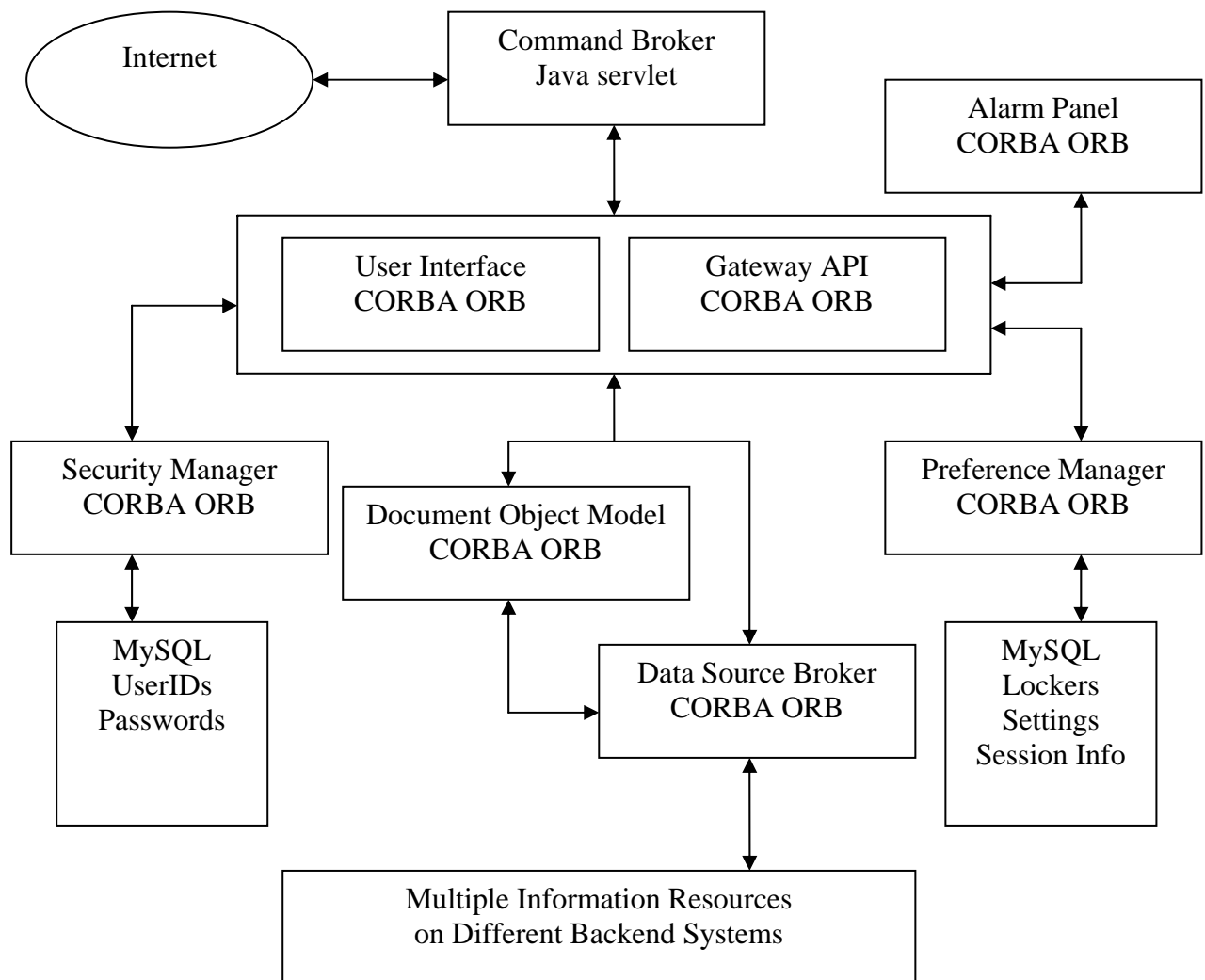


Figure 2. NLM Gateway Functional Diagram

A sample transaction details how the Gateway system works. The user enters query terms and presses the Search button on the Search Screen. The user's browser sends a request to the Command Broker. The Command Broker parses the input data, translating the request into a CORBA method call on the User Interface Manager.

The User Interface Manager receives data from the Command Broker and parses the user input search string into its component parts. It loads these into the Gateway Document Object Model (DOM) server as a search document. The User Interface Manager then tells the DOM to create an empty result document. The User Interface Manager next processes the user's settings and the input from the browser to determine how many items to retrieve and what fields the user wishes to display in brief or in expanded records. Using this information, it finishes filling in the search document stored in the DOM. The User Interface Manager then sends the search document pointer and the result document pointer to the Data Source Broker (DSB), which reads the search document from the DOM.

Working with this information, the DSB translates each term of the search query in accordance with Gateway rules for each of the databases. The resulting translation is copied back into the DOM. Searches for each of the databases requested in the search document are spawned as separate threads sent in parallel. As each database returns its results, the DSB transforms the data from the database's native format into the Gateway's internal format, designed to be independent of any of the backend databases and to hold result sets from any arbitrary database. As each record is translated, it is stored in the DOM's result document. Any errors or warnings are also stored in the DOM's result document.

When all data have been received (or contact with the last backend system to respond has timed out), the DSB returns control to the User Interface Manager. The User Interface Manager checks to see whether all the requested data was received. If not, it sets one or more error flags. It then passes the search document and the result document pointers and control to the Formatter. The Formatter has been informed by the User Interface Manager which page the user is on, so it selects the correct page template to render the page. Following our template design macros, it knows to extract and display various pieces of data that have been passed to it by the User Interface Manager. Eventually it reaches the part of the template that tells it how to format a citation, at which point it requests the citation record data from the DOM.

Following the processing instructions in the template, in several configuration files, and in the user settings, the Formatter generates an HTML page based on the Gateway cascading style sheets using the data retrieved from the DOM. The completed HTML page is returned to the User Interface Manager, which returns it to the Command Broker, which sends it to the user's browser using the Apache web server.

Several other interactions happen behind the scenes. When the browser first communicates with the User Interface Manager, if no session ID is present or the session ID is stale, the User Interface Manager requests a new session ID from the Security Manager.

A user invoking the Locker or the Limits/Settings button from the features bar is given an opportunity to log in. Once the user logs in, a call is made to the Preference Manager. The Preference Manager supplies the user's current set of settings, which override corresponding data in the master settings configuration. Many elements are configurable using the user

settings.

At each important event, a log message is sent to the Alarm Panel to record the progress and operation of the system. These logs will be used later to provide statistical reports of system usage.

5.3 Core of the Gateway: Search Translations and Results Display

At the heart of the Gateway is its ability to accept a user's search and translate it into the series of search statements needed by each of the retrieval systems the Gateway can access. This process is accomplished by the Data Source Broker. The search translation algorithms are created by a trained medical librarian on the Gateway team in consultation with the NLM experts responsible for the retrieval systems. Some of the search algorithms build on mapping techniques first applied by NLM in the earlier Coach [1] and Internet Grateful Med systems. They are then tested carefully to confirm that the Gateway achieves search results comparable to those of the native interface whenever feasible. A very small fraction of the search translation maps for the original NLM Gateway is shown in Figure 3. A complete set of the search translation maps for the new NLM Gateway is presented in Appendix D in Microsoft Excel in a separate printable file. They make very interesting reading.

Recall that the User Interface ORB parses the user's input. The Data Source Broker ORB translates the parsed input to search statements appropriate to each of the multiple retrieval engines accessed by the Gateway. In order of preference, the operators are “”; (); IS, []; NOT; AND (represented by “AND” or by terms separated by a space), OR; #. All two-character subheadings are translated to the complete subheading. All languages are translated to their three-character representation. Quotes and parentheses are removed from PubMed searches. Asterisks are removed from Verity searches (the asterisk signifies a wildcard character in Verity).

Database	PubMed	LOCATORplus	Meeting Abstracts (Verity)
<i>Type of Search</i>	<i>Program Action</i> [LC = LowerCase]	<i>Program Action</i> [SH = subheading(s)]	<i>Program Action</i>
AUTHOR (AU)	LC(Echo), append [AU]	NA	Parse; (LC(last name) <EXACT> <IN> LNAME AND LC(initials) <IN> INITIALS AND LC(suffix) <IN> SUFFIX) <IN> AUTHOR
MeSH (MH)	If no SH: LC(Echo), append [MH]. With SH: Entry for each SH separated by OR operator; LC(Echo) / SubheadingLookup(Echo) append [MH]	If no SH: MeSHLookup (Echo) /u=25; t=1 (MeSH Subject). With SH: Entry for each SH separated by OR operator; MeSHLookup(Echo) /u=25; t=1 (MeSH Subject) AND SubheadingLookup(Echo) /u=25; t=1 (MeSH Subject)	If no SH: MeSHLookup(Echo), remove parentheses, append <EXACT> <IN> KEYWORD_LIST. With SH: Entry for each SH separated by OR operator; MeSHLookup(Echo), remove parentheses, append <EXACT> <IN> KEYWORD_LIST
SUBJECT (SU)	Parse into phrases or user quoted phrase; Entry for each phrase separated by AND operator; LC(phrase)	Parse into phrases or user quoted phrase; Entry for each phrase separated by AND operator; LC(phrase) /u=1016 (KeyWordAnywhere) OR MeSHLookup(phrase) /u=25; t=1 (MeSH Subject) OR SubstanceNameLookup(phrase) /u=1016 (KeyWordAnywhere)	Parse into phrases or user quoted phrase; Entry for each phrase separated by AND operator; LC(phrase) <IN> TITLE OR LC(phrase) <IN> ABSTRACT OR LC(phrase) <IN> KEYWORD_LIST OR MeshLookup(phrase) <EXACT><IN> KEYWORD_LIST OR SubstanceNameLookup(phrase) <EXACT> <IN> KEYWORD_LIST OR LC(phrase) <IN> SPACE_FLIGHT_MISSION

Figure 3. Small Fraction of the NLM Gateway Search Translation Maps

For a gateway system dealing with disparate retrieval systems, it may be as important to display results coherently as it is to translate searches correctly. Each of the retrieval systems presents results in its own format, with its own look. As noted above, the Gateway's Data Source Broker accepts these results, parses them into a canonical Gateway form in XML, and stores them in the Document Object Model, the DOM. The Formatter reads them from the DOM in XML canonical form, reformats them according to configuration-table defaults and the user's settings, and sends them to the User Interface Manager for display by the user's browser.

Result formatting can also be seen in a broader view. Navigation of the results from searches across multiple systems opens many avenues of exploration. Soyeon Park [2] defines three types of user interaction with the results of multiple database searches.

1. Separate interaction: the user is connected to each system involved and must understand how to use the capabilities of multiple systems and also merge the results from multiple system searches;
2. Common interaction: a single interface for searching different resources so that users do not need to know specific query languages and techniques specific to each source but still need to repeat actions as they move from one source to another as well as integrate the results; and
3. Integrated interface searches: the interface searches multiple sources and the user interacts with the integrated results but is unable to take advantage of characteristics unique to the individual sources.

The results of Park's study indicate that users prefer Type 2 and Type 3 to Type 1, with Type 2 having a slight edge. The preference for Type 2 was largely based on the fact that users could select the databases to search once they were familiar with the options. However, the preference for Type 3 was based on the utility of the integration of the results. Interestingly, we have some of the characteristics of all three types of user interaction in the systems discussed in this paper.

NLM's former Internet Grateful Med was a Type 2 system (common interaction) with some aspects of a Type 1 system. The user chose a database and searched in that database individually, but from a series of search screens that had a deliberately coherent look and feel. Results were presented from only one system at a time, with a concerted effort made to carry across search terms and other search elements from the previous search as appropriate when a user changed databases.

Another system, NLM's former HSTAT (Health Services/ Technology Assessment Text) [3] was also a Type 2 (common interaction) system. That is, the user selected multiple sources to search and the HSTAT client reformulated the query as necessary for other systems. The results, however, were not integrated. The HSTAT results were followed by the results from each additional site selected. To view the expanded results from another site, the user was taken to that site (and then had the option of refining the search using site-specific capabilities). HSTAT efforts in agent technology [4] addressed the desirable goal of integrating search results from multiple sources.

The Gateway is more nearly a Type 3 (integrated interface) system. The interface searches multiple sources and the user receives an integrated results summary count showing numbers for each document collection. This saves time and saves load on the target retrieval systems; the user can call up results from any document collection with a single mouse click, but may not always choose to do so.

The search translations and the results formatting happen behind the scenes, but they are the keys to the Gateway user's experience in seamless simultaneous searching of multiple retrieval systems.

5.4 Dynamic Context Leads to Gateway Functional Enhancements

The NLM Gateway team has chosen a challenging task: standing on shifting sands, aiming at moving targets. By its very nature, a meta-searching system is dependent on multiple backend systems over which it may have little or no control. They may enlarge, contract, change, reorganize, or transmogrify completely at varying rates. The Gateway developers have been fortunate that for the most part, NLM colleagues responsible for the systems the Gateway searches have been helpful and cooperative. Each of those systems is itself under rapid development, with its own priorities and its own external stimuli. Data formats change, APIs change, system load capacity changes, network loads affect performance, technical personnel change – the list of external factors that can affect the NLM Gateway is a long one. However, the dynamic context often brings new opportunities for functional enhancements that improve the Gateway user experience. Developments in other groups sometimes provide fertile ground for useful improvements.

The UMLS mapping file improves retrieval by adding important entry terms. The file facilitated the Gateway team's creation of a phrase detector that made it possible to eliminate the requirement that Gateway users surround multiword phrases in a search query with quotation marks. A spell checker from the Natural Language Systems group has been helpful. New releases of the UMLS Metathesaurus, now quarterly, provide increased coverage of terms and concepts. These more-frequent releases prompted the creation of automated processes that handle the huge Metathesaurus updates more smoothly in less time.

The Indexing Initiative created a machine indexing process that after development and tuning was ready to try in production. The Gateway was the first NLM production system to use it, with machine indexing of the Meeting Abstracts collection of about 100,000 records searched in the Verity retrieval system that is a Gateway component.

The PubMed team created the LinkOut function. The Gateway team added LinkOut functionality as well as "free full text" links added at the request of NLM management. Access to the PubMed search filters was incorporated. The Medline Document Type Definition (DTD) was incorporated and its changes tracked as they occurred. PubMed absorbed OLDMEDLINE, which had formerly been in the Gateway's Verity system. Changes made to the Entrez suite of APIs by NCBI were tracked. Changes in the Gateway interaction were made when necessary. Sometimes the changes allowed new capabilities or data enhancements to be exploited by the NLM Gateway.

The Books/Serials/AVs database LocatorPlus was searched by the original NLM Gateway using the Z39.50 interface and Java Database Connectivity calls. When this catalog data was replicated and absorbed into Entrez as the NLM Catalog, the Gateway team took advantage

of Entrez's advanced searching capabilities and provided Gateway users with catalog data from that resource.

A number of changes have occurred at the TOXNET site from which the Gateway searches TOXLINE Special, DIRLINE, and the Hazardous Systems Data Bank (HSDB). APIs were improved as experience showed occasional problem areas. New capabilities have come on line in TOXNET that will be very useful, including a portal function that looks across multiple TOXNET databases.

The NLM Gateway from its initial public release ran on a small server farm of Sun machines running the Solaris operating environment. Redundancy was carefully added to reduce the potential for single points of failure. Two front machines, two or four middle machines, and two back machines were used. The Resonate load balancing system apportioned user load across the front, mid, and back pairs quite well. Individual machines could be taken down for updating or software maintenance without affecting users. During 2003-2004, NLM embarked on a major initiative to create a remote collocation site to keep the production systems up and running if a disaster befell the main NLM machine room. The Gateway team created a new server farm at the remote site in northern Virginia, with Resonate sharing the load across the separate sites and within each server farm. The user load from the outset was handled 50%/50% at each site.

A series of scripts that comprise a "heartbeat" monitoring system keeps tabs on the many functional components of the NLM Gateway in both locations. E-mail notifications are sent when exceptions are detected.

A requirement that Federal computer systems be compliant with Section 508 of the Americans with Disabilities Act led to careful testing of the Gateway systems to assure compliance. Only small remediations were necessary; the systems were almost in full compliance from the outset.

Beginning with the design for the new NLM Gateway, the system code was developed with a move from the Sun/Solaris platform to Dell Intel servers running Linux. This has been quite successful; the new system is running on relatively inexpensive Linux boxes. The changeover will be completed when the collocation site is also moved from Suns to Linux boxes.

An exploration of some aspects of information visualization and of apparent "best practices" on widely used Internet sites informed the interface design of the new NLM Gateway. The overall cleaner, simpler look and quicker navigation through the new system resulted. The tabbed interface of the Limits/Setting function derives from this work, as does the ability to use these settings for a single session without having to log in. When the user has set limits, they appear right in the banner bar so it is clear that they are applied for this session.

User feedback was carefully considered and taken seriously. Analysis of the user action logs helped the team understand what users were, and were not, doing. The ease of jumping from one result set to another in the new system is a direct response to the observation that users seldom went beyond the display of the first collection in a results category (for instance, PubMed in the journal article citations category) in the original system. Sometimes good results were present elsewhere in a collection the user never got to. The procedure for e-

mailing results to one's self or others has been clarified (the original NLM Gateway is believed to be the first of NLM's online systems to be able to e-mail a result set).

5.5 Screen Comparisons, Old and New

Appendix A of this manuscript presents a brief series of captured screen shots that graphically illustrate some of the differences between the original NLM Gateway of October 2000 and the redesigned NLM Gateway of April 2005. Figure A1 is the front screen of the original system, during the period it was running in parallel with the new Gateway. It had a "Try our new look" pointer to the new system to lead users gently in that direction. Figure A2 is the front screen of the new system. Note that it clearly shows that the user's search will happen across the whole set of databases listed on the screen. Each of those names is a direct link to that site if the user chooses to take a look.

Figure A3 is the Results Summary screen for the original Gateway for the search "macular degeneration". It shows hit counts by result category, not by database collection. The user choosing "Display Results" is taken to results for the first collection in that category. The "Jump to Collection" button is the means of moving to other collections in the category. Figure A4 is the Results Summary screen for the new Gateway for the same search. It shows hit counts directly for all 15 collections searched. The user clicks on any of the 15 collections to jump directly to the first page of results for it.

Figure A5 is the next step, the first page of results for the first collection (PubMed) in the Journal Citations category in the original Gateway. The user must use "Jump to Collection" to go to another collection in the Journal Citations category. To move to one of the other categories, the user must go back to the results summary page and choose "Display Results" in that category. Figure A6 is the first page of results for the PubMed collection in the new NLM Gateway. Jumping to another page in the same collection is simpler, selecting an action (download, email, put in locker, order document) is simpler, and the column down the left side offers one-click jumps to results from any of the other 14 collections.

Figure A7 is the Limits page from the original Gateway. Several limits are available, and the user can specify how many items per page to display on a results page. Figure A8 is the Limits/Settings page for the new NLM Gateway. Its tabbed interface offers access to a number of functions in a clean, non-confusing way. The user can set Search Limits, Results Settings, Select Fields, and Download/Display options from this screen. Once made, these settings can be applied to the current session without a login, or saved with a login to apply to this and future sessions in which the user has logged in.

We hope users will respond well to the new look. Time will tell.

5.6 User Activity Logs

Each screen button-click made by a user is captured in an activity log. There is no identifying data by which we could tell who the user is; we simply capture the action so we can tell what users are doing. Analysis of the logs helps pinpoint which functions are most widely used and perhaps should be optimized, which functions are not used or seldom used, and even which might be used in error, leading us to consider changes in the user interface or the screen captions and labels. Appendix B is an analysis of one year's worth of activity log data totaling 7.7 Gbytes. Explanatory comments are present in the appendix itself.

6.0 Evaluation Plan

Information science researchers have been evaluating retrieval systems searching individual databases for decades. The evaluation of systems that simultaneously search multiple databases on multiple retrieval engines is somewhat different, and necessarily more complex. Harter notes that documents come and go, schemas evolve, and retrieval algorithms change [5]. One could perhaps do precision and recall tests on each of the databases searched, then produce a composite measure. The dynamic, regularly updated nature of the databases searched by a production system such as the Gateway adds to the challenge.

Deciding what to evaluate is not always straightforward. Robertson suggests that one approach is to consider three properties of a retrieval system: its effectiveness, how well it satisfies the designer's intent; its benefits or usefulness; and its efficiency or performance [6]. There are other elements still more difficult to quantify. One is the convenience of having single-point access to multiple knowledge resources. This might be balanced against the possible lack of specificity caused by having one common-denominator search screen that may not take advantage of some of the specialized characteristics of some of the databases.

One measure of the utility of any system like the NLM Gateway is usage. If we find that people seek it out and use it for an overview scan rather than going serially to the native interfaces of each of the systems it accesses, the Gateway is doing its job. User satisfaction can be ascertained through user comments and responses to brief surveys. There is another utility that intuitively seems important but is more difficult to measure. This is the fact that the Gateway will be able to get the information in NLM's less-known databases before the public: there is real worth in presenting useful information the user never knew existed, from a database he didn't know to try.

7.0 Project Schedule

As noted in the Status Report, the comprehensively redesigned new NLM Gateway was brought up in parallel with the original Gateway April 4, 2005. The new system becomes the default on April 18, 2005. The original system is retired May 2, 2005. With the new system in place, the development team looks forward to addressing research issues as well as continuing work on user improvements and the Gateway infrastructure.

Based on feedback from the beta test of the redesigned Gateway, MedlinePlus searching will be enhanced so that results match those received on the MedlinePlus site itself. Previously, searches more closely matched NLM home page search results for MedlinePlus. A new collection, MedlinePlus - Other Resources, will be introduced for databases, organizations, directories, and the like. These results are currently displayed under Health Topics. Health Tutorials displayed as a separate collection will be retired; tutorials will be displayed under Health Topics, as is done on the MedlinePlus site. Results that are external links will be added in the Health Topics collection, displaying in relevance ranked order after all MedlinePlus health topics pages.

The NLM Gateway will provide access to the NCBI Bookshelf in the coming months. The Bookshelf includes molecular biology textbooks, *Medicine in the Americas: Historical Works*, *Health Services/Technology Assessment Text (HSTAT)*, and NCBI resources. "Medicine in the Americas" is a digital library project providing scanned historical American medical books and searchable versions of the texts. The *Health Services/Technology Assessment Text* is a free Web-based resource of full-text documents that provide health

information and support health care decision making. HSTAT's audience includes health care providers, health service researchers, policy makers, payers, consumers, and the information professionals who serve these groups.

The current collection of meeting abstracts is being converted and moved to the NLM DCMS (data creation and maintenance system). The Gateway XML data for these abstracts is being converted to a meeting abstracts DTD that is part of the NLM set of DTDs for publicly accessible data. This project should be complete, with the new data in the Gateway system, sometime later this spring or summer. The Gateway system will continue to provide search access for meeting abstracts, but Gateway staff will no longer have to provide data creation support. This will be a welcome change, as sets of abstracts have been received in a wild variety of strange formats in the past.

Along with new meeting abstracts data, investigation has begun on replacing the Verity full text search system with the SE full text search system. SE is an NLM system that currently provides search capabilities for ClinicalTrials.gov and Profiles in Science.

In the longer term, the NLM Gateway will consider providing access to NLM's Images from the History of Medicine and to the Profiles in Science site.

8.0 Summary

The NLM Gateway has been in production since October 2000. It should be noted that the component nature of the Gateway makes it readily adaptable for the addition of new features. Alternate ways of interpreting and translating searches input by the user are possible, as well as additional help modules. One that has been discussed has been a search page that would perform as a "digital librarian" or "search wizard", walking the user through a set of forms comprising a reference interview and building the search from that input. Other similar new modules, readily pluggable into the component system, offer significant opportunities for using the NLM Gateway system as an infrastructure for retrieval systems research.

The creation of the NLM Gateway involves research in areas such as user interfaces for naïve users; search formulation given multiple resources; transaction log analysis including data mining; system adaptation to user actions; and deduplicating, ranking and presenting the results of multiple simultaneous searches in several retrieval systems. Many hooks into system functions will create an environment that facilitates experimenting with aspects of the user interface. Various options on both the input side (helping users choose among clusters of databases) and the output side (presenting clear options for displaying results from searches in multiple databases) are worth exploring.

There are interesting research issues in parsing user queries to provide command statements appropriate to different retrieval systems, user profiling, and source selection to highlight collections most likely to have relevant responses. Domenig and Dittrich have done interesting work in some of these areas [7], as have French and Viles [8]. Soergel has concisely stated useful goals for powerful search functions that combine information across databases in [9]. We will track and test developments in methods for maintaining state when necessary in Web transactions. We will continue to explore means of load testing and load balancing. We will consider load quantifying and throttling when necessary to detect and minimize the effects of denial-of-service attacks.

Finally, with NLM's increasing emphasis on providing information to patients, their families and the public, it becomes even more important to continue exploring creative methods of

transforming the queries of consumer-level users to those medical terms more likely to get good retrieval from professionally indexed databases.

We have presented the background, the current status and the development plans for an NLM Gateway that offers single-point access to multiple NLM knowledge resources. The system's design makes a concerted effort to build on the strength of the intelligent gateway concept: the ability to offer value-added capabilities the user did not know to ask for.

9.0 Acknowledgments

We acknowledge with gratitude the intellectual contribution and dedicated efforts of a talented group of software developers in the design and development of the NLM Gateway. Dr. Xiaocheng Luan*, Mr. Ajay Kanduru**, and Ms. Sharada Jayanna* were instrumental in creating the new NLM Gateway, sometimes building on the contributions of other technical staff who came before them. Our colleagues in the Medlars Management Services section of NLM's Division of Library Operations were extremely helpful in suggesting and refining functionality of the user interface and in performing both operational testing and usability testing. Ms. Maureen Prettyman served with distinction as deputy project leader, contributing in many important ways until her retirement in January 2005. (* Aquilent, ** Taj Technologies)

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- [7] Domenig R and Dittrich K. A query based approach for integrating heterogeneous data sources. In: *Proc CIKM 2000, Conference on Information Knowledge and Management*, McLean, VA, USA, pp. 453-460.
- [8] French JC and Viles CL. Personalized information environments: an architecture for customizable access to distributed digital libraries. *D-Lib Magazine* 5:6, June 1999.
- [9] Soergel D. A framework for digital library research. *D-Lib Magazine* 8:12, December 2002.

Questions for the Board

1. Evaluation of systems that constitute moving targets is a considerable challenge. Interfaces change, back end systems change, user populations change, user patience with the search process changes. Users' experience with systems such as Google seems to have created a drive for simplicity. Does the Board have suggestions for aspects of evaluation that should receive concentrated focus?
2. The NLM Gateway searches multiple back end systems. Some are Boolean in nature and some are not. Some systems provide ranked output; most do not. What does the Board recommend in instances in which the user has consciously made a Boolean search, but one of the back end systems is non-Boolean? Will the user be confused if the Gateway turns the search into a non-Boolean one before sending it to the non-Boolean system?
3. User activity logs provide fertile ground for analysis of the usage (and, sometimes, of the relative success rate) of certain system functions. Are there specific aspects of user behavior the Board would like us to consider concentrating on?

Appendix A: Original NLM Gateway and New NLM Gateway Screen Examples

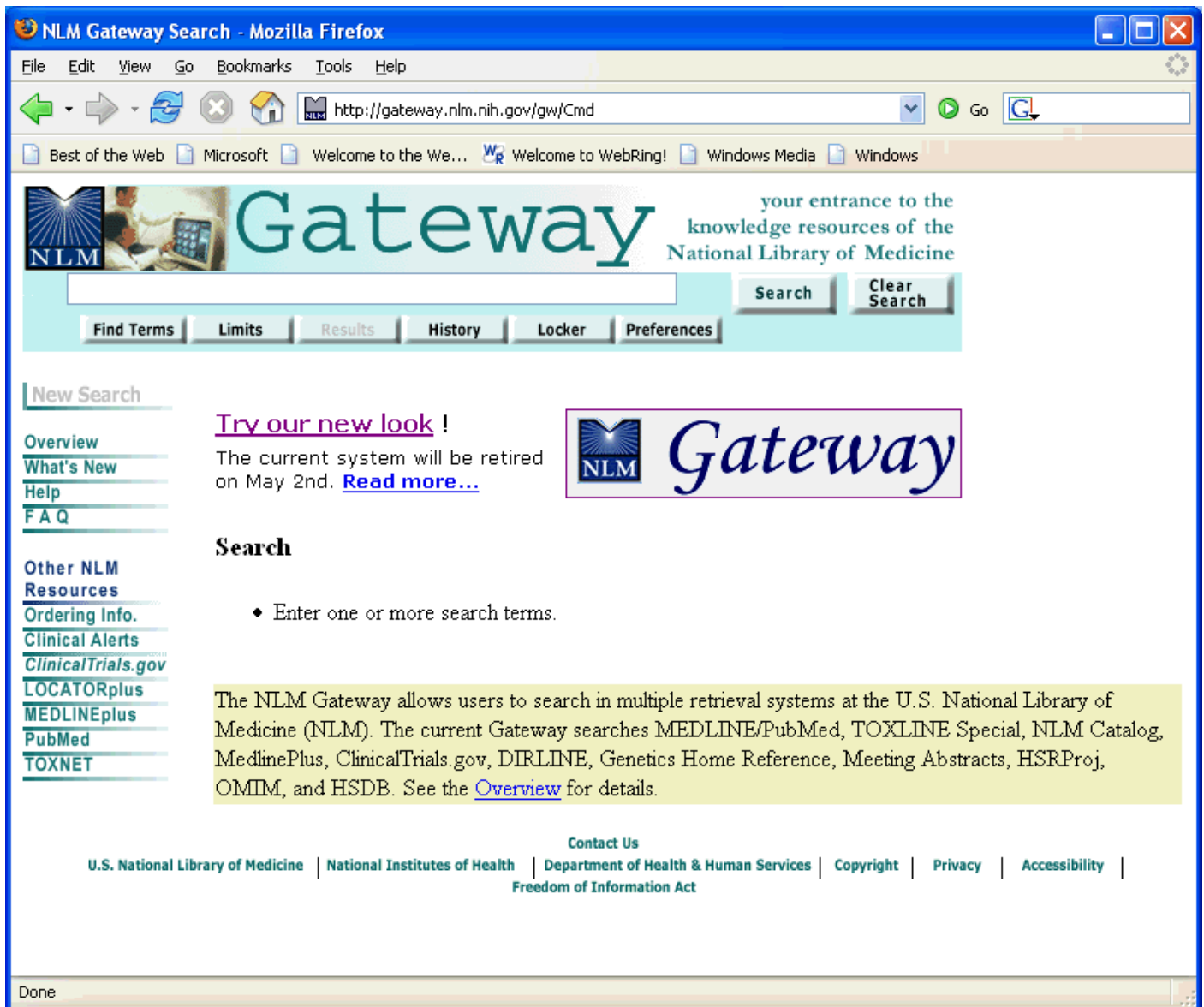


Figure A1. Front screen of the original NLM Gateway during the time it was running in parallel with the new NLM Gateway.

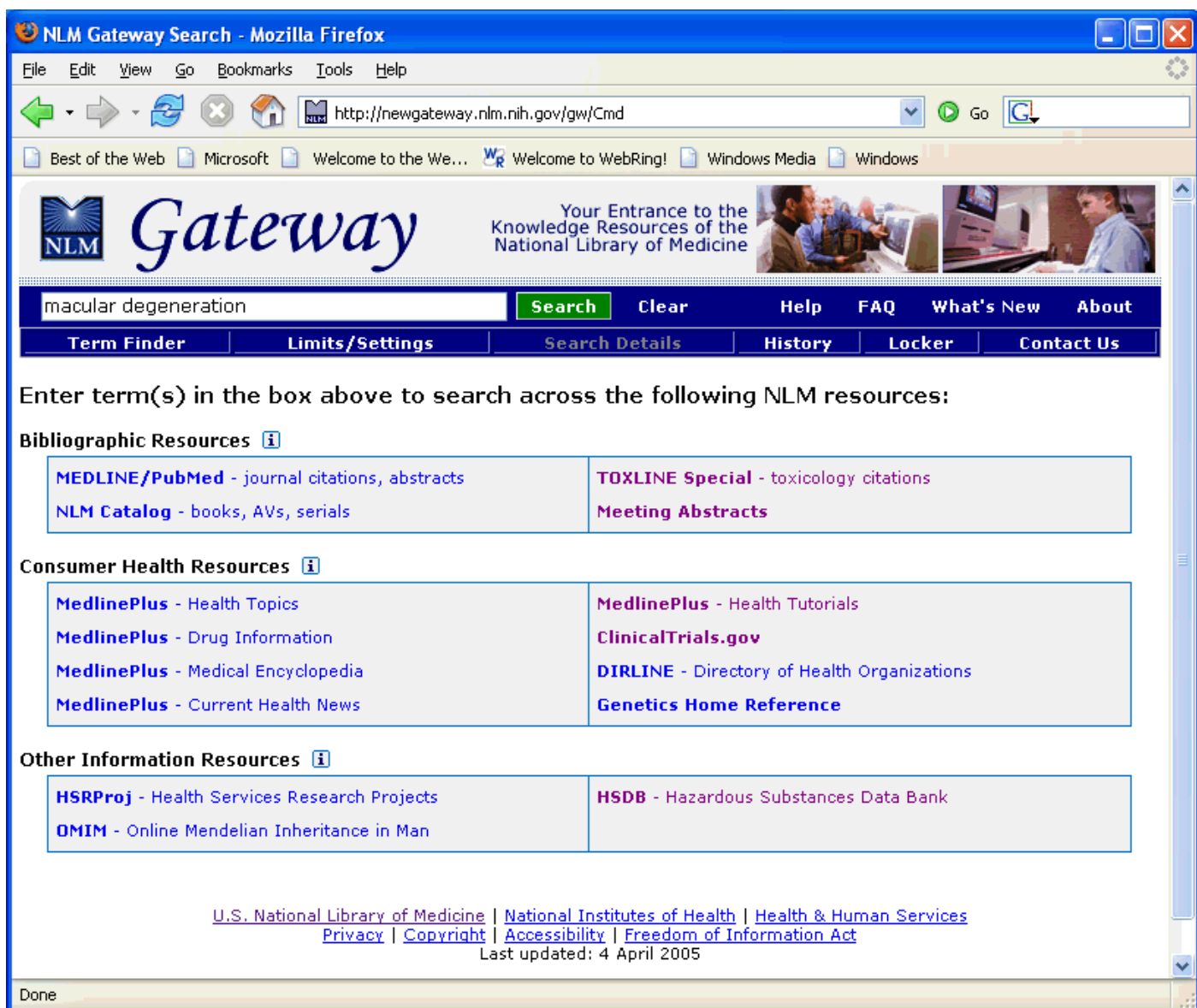


Figure A2. Front screen of the new NLM Gateway, showing systems accessed.

NLM Gateway Results Summary - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://gateway.nlm.nih.gov/gw/Cmd?GMBasicSearch&loc=nccs

Best of the Web Microsoft Welcome to the We... Welcome to WebRing! Windows Media Windows

 **Gateway** your entrance to the knowledge resources of the National Library of Medicine

macular degeneration

New Search

- Overview
- What's New
- Help
- FAQ

Other NLM Resources

- Ordering Info.
- Clinical Alerts
- ClinicalTrials.gov
- LOCATORplus
- MEDLINEplus
- PubMed
- TOXNET

Results Summary

Category	Items Found	Actions	
Journal Citations	7575	<input type="button" value="Display Results"/>	<input type="button" value="Details of Search"/>
Books / Serials / AVs	60	<input type="button" value="Display Results"/>	<input type="button" value="Details of Search"/>
Consumer Health	184	<input type="button" value="Display Results"/>	<input type="button" value="Details of Search"/>
Meeting Abstracts	5	<input type="button" value="Display Results"/>	<input type="button" value="Details of Search"/>
Other Collections	111	<input type="button" value="Display Results"/>	<input type="button" value="Details of Search"/>
Total	7935		

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Done

Figure A3. Results summary page from original NLM Gateway, showing results by category.

NLM Gateway Results Summary - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://newgateway.nlm.nih.gov/gw/Cmd?GMBasicSearch&loc=lhc

Best of the Web Microsoft Welcome to the We... Welcome to WebRing! Windows Media Windows

NLM Gateway Your Entrance to the Knowledge Resources of the National Library of Medicine

macular degeneration **Search** Clear Help FAQ What's New About

Term Finder Limits/Settings Search Details History Locker Contact Us

Results Summary: **7935 records found** [[Bookmark this Search](#)]

Bibliographic Resources ⓘ

7479 MEDLINE/PubMed - journal citations, abstracts	96 TOXLINE Special - toxicology citations
60 NLM Catalog - books, AVs, serials	5 Meeting Abstracts

Consumer Health Resources ⓘ

22 MedlinePlus - Health Topics	1 MedlinePlus - Health Tutorials
21 MedlinePlus - Drug Information	53 ClinicalTrials.gov
71 MedlinePlus - Medical Encyclopedia	14 DIRLINE - Directory of Health Organizations
2 MedlinePlus - Current Health News	0 Genetics Home Reference

Other Information Resources ⓘ

5 HSRProj - Health Services Research Projects	7 HSDB - Hazardous Substances Data Bank
99 OMIM - Online Mendelian Inheritance in Man	

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Done

Figure A4. Results summary page from new NLM Gateway, showing results by data collection searched.

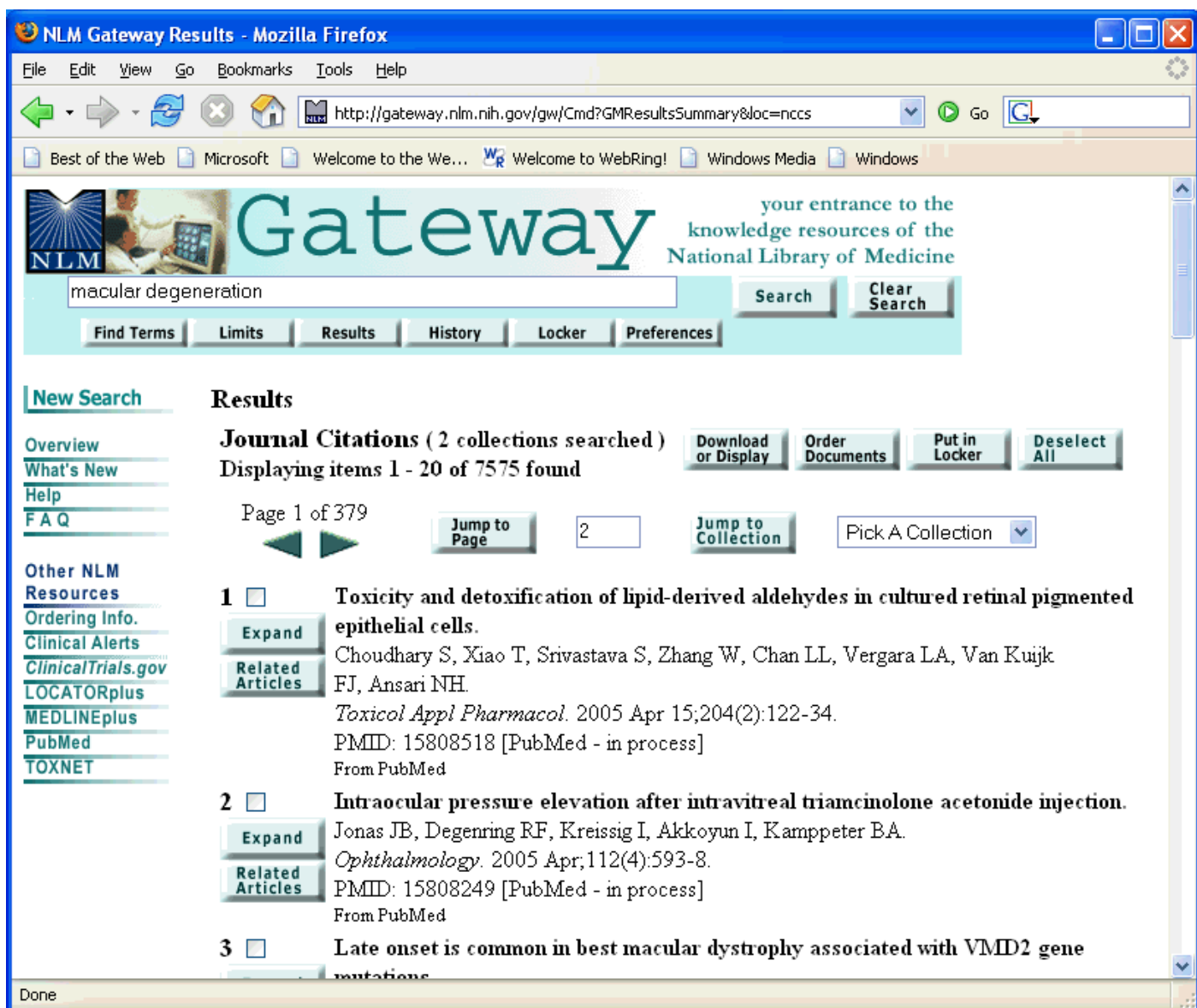


Figure A5. Results page for PubMed collection from original NLM Gateway.

NLM Gateway Results - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://newgateway.nlm.nih.gov/gw/Cmd?GMResultsSummary&loc=lhc

Best of the Web Microsoft Welcome to the We... Welcome to WebRing! Windows Media Windows

NLM Gateway Your Entrance to the Knowledge Resources of the National Library of Medicine

macular degeneration **Search** Clear Help FAQ What's New About

Term Finder Limits/Settings Search Details History Locker Contact Us

Results

Total 7935

Bibliographic

PubMed	7479
NLM Catalog	60
TOXLINE Special	96
Meeting Abstracts	5

Consumer Health

MedlinePlus ...	
Health Topics	22
Drug Info	21
Med Encyclopedia	71
Health News	2
Health Tutorials	1
ClinicalTrials.gov	53
DIRLINE	14
Genetics Home Ref	0

Other Resources

HSRProj	5
OMIM	99
USP	7

Done

PubMed Results (Items 1 - 20 of 7479)

◀ Prev Page 1 of 374 Next ▶ Select an action ▼ Go

- Toxicity and detoxification of lipid-derived aldehydes in cultured retinal pigmented epithelial cells.**
Choudhary S, Xiao T, Srivastava S, Zhang W, Chan LL, Vergara LA, Van Kuijk FJ, Ansari NH.
Toxicol Appl Pharmacol. 2005 Apr 15;204(2):122-34.
PMID: 15808518 [PubMed - in process]
[Related Articles](#)
- Intraocular pressure elevation after intravitreal triamcinolone acetonide injection.**
Jonas JB, Degenring RF, Kreissig I, Akkoyun I, Kampeter BA.
Ophthalmology. 2005 Apr;112(4):593-8.
PMID: 15808249 [PubMed - in process]
[Related Articles](#)
- Late onset is common in best macular dystrophy associated with VMD2 gene mutations.**
Renner AB, Tillack H, Kraus H, Kramer F, Mohr N, Weber BH, Foerster MH, Kellner U.
Ophthalmology. 2005 Apr;112(4):586-92.
PMID: 15808248 [PubMed - in process]
[Related Articles](#)

Figure A6. Results page for PubMed collection from new NLM Gateway.



Figure A7. Limits page from original NLM Gateway.

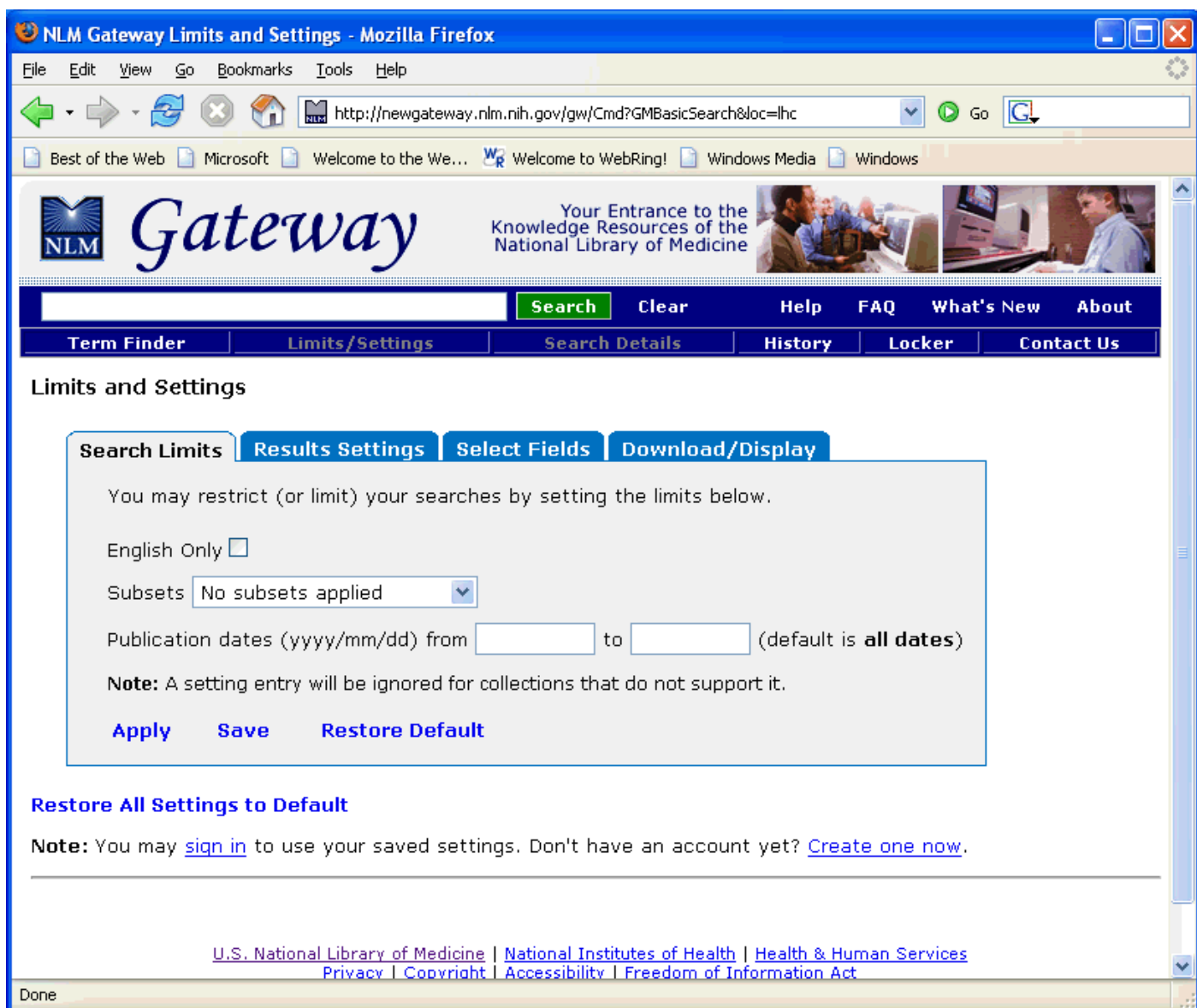


Figure A8. Limits/Settings page from new NLM Gateway. Note tabbed interface.

Appendix B: Analysis of User Activity Logs July 1, 2002 through June 30, 2003

The counts represent "button clicks" derived from 7.7 Gbytes of log data from the original NLM Gateway over a period of one year.

Some of the buttons (e.g., "Jump to Page", "Cancel") are used in more than one page; no attempt was made to separate them.

Activity Buttons on the Top Menu Bar

=====

Perform Search	1,460,212
Clear Search	43,190
Find Terms	81,021
Limits	105,628
Results Summary	9,171
History	26,522
Locker	20,939
Preferences	20,854

Activity Buttons on the Side Menu Bar

=====

New Search	13,957
Overview	185,056
What's New	5,641
Help	21,713
FAQ	10,431

Actions on the Find Term Pages

=====

Find MeSH Term	86,526
Related Concepts	4,619
View MeSH record	3,906
Add to Search	45,810
Subheading Definitions	94
Cancel	731

Actions on the Results Summary Page

=====

result-journal	686,520
result-books	58,681
result-consumer	35,303
result-meeting abs.	26,255
result-other	10,832

search details 59,846

Actions on the Results Pages

download/display 117,763
order Docs 19,169
put in locker 32,599
deselect all 1,989
jump to page 211,558
jump to collection 27,444

expand item 1,005,149
see related 143,553
publisher link 30,915

Actions on the Search History Page

clear history 621
history delete item 4,858
history results 6,057

Actions on the Login, Locker, Preferences Pages

Login 12,768

Apply to this session 1,494
Save Preferences 1,189
Restore Defaults 173
Restore_All 93
Change Password 65

locker delete item 7,853

("download/display" and "order documents" are included in "Results Pages")

Some observations by team member Dr. Xiaocheng Luan, who did the analysis:

1. The order in which we placed our categories (e.g., Journal Citations) is consistent with the number of accesses each receives.
2. A category was selected for, at most (or about), 56% of the searches. "About," because "Results Summary" to return to that display was rarely used, therefore most of the time a category was selected immediately following a search and no other category was examined.
3. Other than "Search", "Limits" is the most frequently used button on the primary menu bar. This is probably not a surprise.

4. The "Locker" and "Preferences" actions have similar frequency. These are probably users who like to explore (and, by extension, use) the various features.
5. "Find term" has been used fairly frequently. Most uses of "Find term" were about "Find MeSH Term". More than half of the time that "Find terms" was used, "Add to Search" was used. This indicates that the user found a term he wanted to search with.
6. "Results Summary" is the least used button on the primary menu bar. This is a bit surprising.
7. "Overview" was used significantly more than "Help," "FAQ," or "What's New".
8. "Jump to page" was used significantly more than "Jump to collection".
9. "See related" was fairly frequently used, about five times as often as "Publisher link".
10. Since some developers and testers used the system too, the "Restore all" and "Restore defaults" functions were almost never used by real users.
11. Many people did use the "Expand" button on the result page.
12. The "Journal Citations" category attracted most of the traffic: 84%.

Appendix C: Curricula Vitae

Name: Lawrence C. Kingsland III, Ph.D.

Position Title: Assistant Director for Applied Informatics, NLM
Chief, Computer Science Branch, LHCNBC
Gateway Project Leader

Education and Training:

Institution	Degree	Year	Field of Study
Brown University	A.B.	1966	International Relations
University of Missouri-Columbia	M.S.	1973	Electrical Engineering (Bioengineering concentration)
University of Missouri-Columbia	Ph.D.	1980	Electrical Engineering (Bioengineering concentration)
University of Missouri-Columbia	Post-doctoral Fellow	1980-1984	NLM Training Program in Health Sciences and Computer Technology

Research and Professional Experience:

Research -

NLM Gateway, for assisted searching in multiple retrieval systems simultaneously from a single Web address
Internet Grateful Med, for assisted searching in any one of 15 NLM databases
Coach expert search refinement system, adjunct program for users of NLM's MS-DOS Grateful Med program
Coach Metathesaurus Browser, for browsing of NLM's Unified Medical Language System Metathesaurus under MS-DOS
Clinical testing, validation and evaluation of medical expert systems
CTX, WinCTX, WebCTX multimedia expert system shells
AI/Rheum diagnostic consultant system in rheumatology
Criteria table form of knowledge representation for expert systems
AI/Coag consultant system for problems in human hemostasis

Employment -

1993-present Assistant Director for Applied Informatics, NLM
1987-present Chief, Computer Science Branch, LHCNBC
1984-1987 Head, Expert Systems Program, LHCNBC
1980-1984 Research Associate, Information Science Group,
University of Missouri-Columbia

Honors -

Federal Showcase Site Award, Federal Webmaster Workshop, 1996
NIH Director's Honor Award, 1996
NLM Director's Honor Award, 1993
NIH Award of Merit, 1988
Fellow, American College of Medical Informatics, elected 1985

Publications:

Proceedings Edited

Kingsland, LC III, ed. Proceedings of the Thirteenth Annual Symposium on Computer Applications in Medical Care (SCAMC 1989). Washington, DC: IEEE Computer Society Press, 1989;1062.

Book Chapters

Kingsland, LC III: Evaluation of Medical Expert Systems: Experience with the AI/RHEUM Knowledge-Based Consultant System in Rheumatology. In Perry L. Miller, ed. Topics in Medical Artificial Intelligence (New York: Springer-Verlag, 1988), 212-221.

Manuscripts

Kingsland, LC III; Prettyman, MF; Shooshan, SE. The NLM Gateway: a metasearch engine for disparate resources. In: Fieschi M, Coiera E, and Li YCJ, eds. MEDINFO 2004: Proc 11th World Congress on Medical Informatics. Amsterdam: IOS Press, 2004;52-6.

Athreya, BH; Cheh, ML; Kingsland, LC III. Computer-assisted Diagnosis of Pediatric Rheumatic Diseases. Pediatrics 1998 102:e48.

Kingsland, LC III; Harbourt, AM; Syed, EJ and Schuyler PL. Coach: applying UMLS knowledge sources in an expert searcher environment. Bull Med Libr Assoc 1993 Apr;81(2):178-83.

Harbourt, AM; Syed, EJ; Hole, WT and Kingsland, LC III: The ranking algorithm of the Coach browser for the UMLS Metathesaurus. In: Safran C, ed. Proc Seventeenth Annual Symposium on Computer Applications in Medical Care. New York: McGraw-Hill, 1993;720-4.

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Porter, JF; Kingsland, LC III; Lindberg, DAB; Shah, I; Bengte, JM; Hazelwood, SE; Kay, DR; Homma, M; Akizuki, M; Takano, M; Sharp, GC: The AI/RHEUM knowledge-based computer consultant system in rheumatology: performance in the diagnosis of 59 connective tissue disease cases from Japan. Arthritis and Rheumatism 31(2):219-226; February, 1988.

Kingsland, LC III; Lindberg, DAB; Sharp, GC: Anatomy of a knowledge-based system: AI/RHEUM. MD Computing; Volume 3, Number 5; September/October, 1986: 18-26.

Kingsland, LC III: Artificial intelligence: promise and reality. Invited tutorial paper. Proc American Association for Medical Systems and Informatics (AAMSI) Congress 1986. Washington, D.C.: American Association for Medical Systems and Informatics, 1986: 87-91.

Kingsland, LC III and Lindberg, DAB: The criteria table form of knowledge representation in medical artificial intelligence. Proc Fifth Conference on Medical Informatics (MEDINFO 86). Amsterdam: North-Holland, 1986;12-16.

Name: Sonya E. Shooshan, M.L.S.

Position Title: Information Research Specialist

Education and Training:

Institution	Degree	Year	Field of Study
Radcliffe College and Harvard University	A.B.	1979	Economics
University of Maryland at College Park	M.L.S.	1995	Health Sciences Librarianship

Research and Professional Experience:

Research -

- NLM Gateway, for assisted searching in multiple retrieval systems simultaneously from a single address
- Internet Grateful Med, for assisted searching in any one of 15 NLM databases
- PubMed, for searching in MEDLINE
- ELHILL and MEDLARS databases (technical support, testing)

Employment -

- 2000-present Information Research Specialist, LHCBC, National Library of Medicine
Team member, Gateway development and Internet Grateful Med development. Responsible for testing; investigating and documenting software discrepancies; writing and updating documentation; and coordinating the design team working on the user interface and functionality.
- 1998-2000 Librarian, Division of Library Operations, National Library of Medicine
Tested production and development versions of PubMed; investigated and documented software discrepancies; wrote and updated documentation; participated in design of additional search screens and functionality; monitored data quality. Provided technical support for ELHILL year end processing. Tested MEDLARS databases for weekly and special updates. Provided technical support for data conversion to PubMed, *Locatorplus*, and the Verity full text retrieval system. Monitored data quality for MEDLARS databases.
- 1997-1998 Health Information/Web Development Specialist, The Kevric Company
Contractor providing customer support to NLM for Internet Grateful Med and the MEDLARS service desk. Participated in Internet Grateful Med testing.
- 1997 Web Manager, Sailor Operations Center, Enoch Pratt Free Library, Baltimore, MD. Provided web administration for Sailor and auxiliary web sites. Reviewed and modified site for consistency and ease of use.

- 1996-1997 World Wide Web Project Coordinator, Quantum Research Corporation, Bethesda, MD. Created and modified templates to display data from SQL databases on the World Wide Web.
- 1995-1996 Library Analyst, Aspen Systems Corporation, Rockville, MD. Maintained and upgraded World Wide Web site for the National Criminal Justice Reference Service.
- 1995 Assistant Librarian, National Epilepsy Library, Landover, MD. Provided telephone reference service to library clientele.

Honors -

Miscellaneous NLM Awards

Publications:

Kingsland, LC III; Prettyman, MF; Shooshan, SE. The NLM Gateway: a metasearch engine for disparate resources. In: Fieschi M, Coiera E, and Li YCJ, eds. MEDINFO 2004: Proc 11th World Congress on Medical Informatics. Amsterdam: IOS Press, 2004;52-6.

Shoch, NA; Shooshan, SE. Communication on a listserv for health information professionals: uses and users of MEDLIB-L. Bulletin of the Medical Library Association. 1997 Jan;85(1):23-32.

NLM Gateway online text: Overview, What's New, Frequently Asked Questions, Help text.

Internet Grateful Med online text: Frequently Asked Questions, How to Save a Search Strategy by Constructing an IGM URL, stock replies for correspondence, other user-oriented text materials.

NLM Technical Bulletin articles authored or co-authored:

NLM Gateway Unveils New Design (March-April 2005), Four New Features and Two New Collections in Latest NLM Gateway Release (November-December 2003), NLM Gateway Implements Phrase Detection (March-April 2003), Access to *ClinicalTrials.gov* in the NLM Gateway (January-February 2003), Search Subsets Available in the NLM Gateway Limits Feature (January-February 2003), Automated Indexing Implemented for Meeting Abstracts (September-October 2002), Customizing NLM Gateway Search Results Display (July-August 2001), How to Search OLDMEDLINE Using the NLM Gateway (May-June 2001), Internet Grateful Med to Be Retired; Reminder of NLM Gateway Availability (January-February 2001), NLM Gateway: Your Entrance to the Knowledge Resources of the National Library of Medicine (November-December 2000), Searching POPLINE on Internet Grateful Med (September-October 1999), Internet Grateful Med Update (May-June 1999), Introducing Internet Grateful Med Version 2.6 (July-August 1998).

Technical Reports co-authored:

Aronson AR, Shooshan SE. Ambiguity in the UMLS Metathesaurus 2002.
 Aronson AR, Shooshan SE. Ambiguity in the UMLS Metathesaurus 2003.
 Aronson AR, Shooshan SE. Ambiguity in the UMLS Metathesaurus 2004.

Name: Sharada Y. Jayanna, M.S.

Position Title: Senior Software Engineer

Education and Training:

Institution	Degree	Year	Field of Study
Univ. of Mysore, India	B.S.		Computer Science and Engineering
Birla Institute of Science and Technology, India	M.S.		Software Systems

Research and Professional Experience:

Research -

NLM Gateway, for assisted searching in multiple retrieval systems simultaneously from a single Web address

Employment -

- 2000-present Senior Software Engineer, Aquilent, Inc.
Contractor to the National Library of Medicine, member of the development team for the NLM Gateway meta-searching system. Contributed to many aspects of system development and production support, including the operation of the Verity retrieval system.
- 1999-2000 Consultant, ChannelPoint
ChannelPoint is an eCommerce technology platform provider for insurance and benefits companies. eCommerce solutions enable insurance organizations to conduct business electronically with their distribution partners and customers through web-based buying, selling, and shopping environments.
- 1996-1999 Systems Analyst, ALIT, Inc.
Team member, Seer *HPS, a suite of client/server development tools. The tools can be used to develop ER diagrams, process flow diagrams, and data flow diagrams, and can create code in the HPS Rules language.
- 1996 Consultant, ADA
ADA is a defense agency of the government of India known for research, design, and manufacture of light combat aircraft.

Honors -

NLM Special Act or Service Award

Name: Ajay K. Kanduru, M.S.

Position Title: Senior Software Engineer

Education and Training:

Institution	Degree	Year(s)	Field of Study
Osmania University Hyderabad, AP,India	Bachelor of Engineering	1984	Civil Engineering
Texas Tech University Lubbock, TX	Master of Science	1994	Computer Science

Research and Professional Experience:

Research -- NLM Gateway
Internet Grateful Med
Grateful Med for Windows

Employment --

Senior Software Engineer: 09/1996 - Present

National Library of Medicine (Contract/Taj Technologies Inc.)

NLM Gateway: Team member involved in design, implementation, and production support of this distributed system, designed to search multiple data resources simultaneously from a single Web address. Involved in many aspects of system development, system monitoring, and deployment.

Internet Grateful Med: Responsible for redesign and development of enhancements to this Web application. The program was an on-line Internet search engine providing access to 15 databases on several retrieval systems at the National Library of Medicine. The primary emphasis is on accuracy and efficiency of the search process involving interpretation of ELHILL commands and intuitive visual display of search results. Enhancements involved adding access to new databases and fine tuning searching of the databases.

Grateful Med for Windows: Responsible for design and development of enhancements to cross-platform software using object-oriented design and programming, TCP/IP interface and modem communications. The program interfaced with the ELHILL legacy system, providing the user with a GUI environment on Windows and Macintosh platforms using the XVT cross-platform tool. Enhancements included features to search PREMEDLINE, SDILINE, AIDSLINE, AIDS DRUGS, and AIDSTRIALS.

Software Engineer: 11/1995 – 08/1996

Fisher Controls International (Contract/Donatech Corporation)

FisherFirst: Responsible for providing Other Data Base Connectivity (ODBC) interface for a large Windows application that maintains information about company products, drawings, specifications, customers, order quotations, and pricing. Reorganized the database interfaces to communicate with multiple databases. Responsible for design and implementation in object oriented paradigm for adding additional features to the software.

The features included obtaining technical data from the user, doing Fisher valve/regulator sizing computations, implementing a search algorithm for the product, and retrieving data

from the database. Primary emphasis was on accuracy of sizing computations and efficiency of the search algorithm. Worked with third party GUI libraries to present the graphical data for user interface. The application has ODBC interface with SQL Server and MS Access databases. The program is developed using Visual C++/Microsoft Foundation Classes and third party software tools.

Software Engineer: 09/1994 – 10/1995

Rockwell International (Contract/Donatech Corporation)

Keyboard Menu Definition Editor. Solely designed and implemented a Windows-based application for an international defense client. The programming involved an RS-232 serial port communications interface with a Rockwell developed Global Positioning System (GPS) and a host personal computer. The software lets the user selectively enable/disable the embedded software features of the GPS unit. The user interface involved programming in VISUAL BASIC, Windows API calls, and SDK. The communication protocols involved object oriented programming in C++.

Mission Planning Station. The software was used primarily to program GPS products with their navigation mission data. Responsibilities included enhancing existing software to add multiple GPS products for software interface. Responsible for software interface between Intel x86 and Rockwell GPS using Intel x86 assembly language and DOS interrupts. The programming involved RS-232 serial port communications interface and a DOS-based user interface. Enhanced the software to facilitate use as a much sought after testing utility for GPS embedded software. The software lets the user program a navigation mission on the PC and transfer the mission data to GPS and vice versa. The software also lets the user operate the GPS from the PC.

The program is an MS-DOS-based application written in C.

Software Developer: 04/1991 – 07/1994

Southern Structural Systems Inc., Hyderabad AP, India

Responsibilities included programming in C++ to develop libraries for the design of civil engineering projects. These included major hydraulic structures, road works, and earth works that involved World Bank and IMF aided projects.

Assistant Executive Engineer: 01/1986 – 03/1991

Central Designs Organization, Hyderabad AP, India

Responsibilities included analysis and design of gravity dams, spillways, earthen dams, canals and CD works, involving programming in C/UNIX. Other responsibilities included study of ground water hydrology due to the influence of canal flow involving World Bank and IMF aided projects.

Name: Xiaocheng Luan, Ph.D.

Position Title: Senior Software Engineer (Aquilent)

Education and Training:

Institution	Degree	Years	Field of Study
U. of Sci. & Tech. of China	B.S.	1991	Computer Science
U. of MD, Baltimore County	M.S.	1997	Computer Science
U. of MD, Baltimore County	Ph.D.	2004	Computer Science

Research and Professional Experience:

9/98 – present: Software Engineer/Senior Software Engineer, Aquilent, Inc.

NLM Gateway (1/03 – present), National Library of Medicine
Chief architect for the look and feel of the redesigned Gateway released April 2005. Major contributor to the new user interface design and to multiple aspects of the system, including analysis of the usage of specific system functions.

HSTAT Agent Research (3/99 – 1/03), National Library of Medicine
Architected, designed, and implemented an agent-based framework that can support the extension or integration of legacy software systems in a flexible, scalable, and maintainable way. The framework was successfully used in extending the HSTAT full text medical information retrieval system.

HSTAT Data Tools (9/99 – 1/03), National Library of Medicine
Took part in the design and implementation of the HSTAT data tools subsystem.

HSTAT Batch Client (9/98 – 3/99), National Library of Medicine
Designed and implemented some key modules of the HSTAT batch client query system.

6/98 – 8/98: Intern, IBM T. J. Watson Research Center
Researched fundamental technologies in Electronic Commerce. Designed and implemented logic program parsers, pre-processors, and converters.

7/96 – 5/98: Research Assistant, Laboratory of Advanced Information Technology, University of Maryland, Baltimore County. Worked on the CIIMPLEX/EECOMS Project, which focused on an agent-based framework for integrated intelligent planning/execution in manufacturing systems and business-to-business electronic commerce in the domain of manufacturing supply chain integration. Responsible for agent system prototyping and system integration.

9/95 – 7/96: Research Assistant, Radiation Ontology Department, University of Maryland at Baltimore
UNIX System/Network Administration and software development.

7/91 – 7/95: Software Engineer, Chinese Academy of Sciences, Beijing
Led the Planimetric Map Generating System project, worked on Surface Modeling project and Reservoir Simulation Workstation project.

Publications:

“System Expansion and Integration with Agents in HSTAT”, Xiaocheng Luan, Maureen Prettyman, and Robert Antonucci. Proceedings of the First Asia-Pacific Conference on Intelligent Agent Technology (IAT '99). Hong Kong, December 14-17, 1999.

“Learning in Broker Agent “(Student Abstract/Poster), Xiaocheng Luan, Timothy Finin, and Yun Peng. Proceedings of the Sixteenth National Conference on Artificial Intelligence (AAAI-99), Orlando, FL, July 18-22, 1999.

“Agent Development with Jackal” (Poster), R. Scott Cost, Tim Finin, Yannis Labrou, Xiaocheng Luan, Yun Peng, Ian Soboroff, James Mayfield and Akram Boughannam. Third International Conference on Autonomous Agents (Agents '99), May 1999.

“Jackal: A Java-Based Tool for Agent Development”, R. Scott Cost, Tim Finin, Yannis Labrou, Xiaocheng Luan, Yun Peng, Ian Soboroff, James Mayfield and Akram Boughannam. Working Notes of the Workshop on Tools for Developing Agents (AAAI Technical Report, AAAI-98).

“Masking Technique in Surface Modeling”, Ganping Sun and Xiaocheng Luan. The Eighth National Conference on CG/CAD, China. October 1994.

“Fitting Curve with Arcs in Numerical Control”, Jianping Song, and Xiaocheng Luan. Machine Design and CAD, 1995.

“Design and Implementation of FFT Parallel Algorithms on Transputer System”, Xiaocheng Luan. Mini-Micro Systems, Volume 13, No.2, February 1992.

Appendix D: Search Translations – the Heart of the NLM Gateway

These translations are found in a separate Microsoft Excel file called “Gateway Search Translations May 2005”. They should be printed and bound with this document.

Parsing	Done by User Interface (UI)
Translation	Done by Data Source Broker (DSB)
Operators (in order of precedence)	" " () [] NOT AND (represented by "AND" or terms separated by a space), OR #

All two character subheadings will be translated to complete subheading

All languages will be translated to their three letter representation

PubMed searches will have quotes and parentheses removed

Verity searches will have asterisks ("*") removed; it is a wildcard character

Database
Backend
Sorting Order
Search Tag
AU
IS
LA
MH
MJ
MH:noexp
MJ:noexp
MH:nomap
MJ:nomap
MH:noexp:nomap
MJ:noexp:nomap
DP
PT
SH
SU
SB
NM
TW
TI
TA
UI

Database	PubMed
Backend	Entrez APIs
Sorting Order	Insert time

Search Tag	Program Action	User Input	Translation
AU	Append [AU]	Humphreys BL [AU]	(Humphreys BL [AU])
IS	Insert dash after 4th character if missing, append [TA]	0002-8223 [IS]	("J Am Diet Assoc" [Journal])
LA	LanguageLookup, append [LA]	polish [LA]	("Polish" [Language])
MH	MeSH processing, append [MH]	digital libraries/trends [MH]	("libraries, digital/trends" [Mesh Terms])
MJ	MeSH processing, append [MAJR]	medical libraries/trends [MJ]	("libraries, medical/trends" [MAJR])
MH:noexp	MeSH processing, append [MH:noexp]	earth planet [MH:noexp]	("earth (planet)" [MeSH Terms:noexp])
MJ:noexp	MeSH processing, append [MAJR:noexp]	neoplasms/diet therapy [MJ:noexp]	("neoplasms/diet therapy" [MAJR:noexp])
MH:nomap	MeSH processing, quote term, append [MH]	surgery [MH:nomap]	("surgery" [MESH])
MJ:nomap	MeSH processing, quote term, append [MAJR]	depression [MJ:nomap]	("depression" [MAJR])
MH:noexp:nomap	MeSH processing, quote term, append [MH:noexp]	cold [MH:noexp:nomap]	("cold" [MESH:noexp])
MJ:noexp:nomap	MeSH processing, quote term, append [MAJR:noexp]	immunosuppression [MJ:noexp:nomap]	("immunosuppression" [MAJR:noexp])
DP	Append [DP]	2005/04/01:2005/06/30 [DP]	((2005/04/01 [PDAT]) : (2005/06/30 [PDAT]))
PT	Append [PT]	published erratum [PT]	(published erratum [PT])
SH	SubheadingLookup, append [SH]	surgery [SH] AND diet therapy [SH]	((("surgery" [MeSH Subheading]) AND ("diet therapy" [MeSH Subheading]))
SU	Quoted: remove quotes, Echo unquoted: phrase detection, insert boolean AND between phrases, Echo	septic shock low blood pressure	((("shock, septic" [MeSH Terms]) OR (septic shock [Text Word])) AND (((("hypotension" [TIAB]) NOT (Medline [SB])) OR ("hypotension" [MeSH Terms])) OR (low blood pressure [Text Word])))
SB	Append [SB]	oldmedline [SB]	("subsetom" [All Fields])
NM	SubstanceNameLookup, append [NM]; if subheading attached, SubheadingLookup, append "AND subheading [SH]"	vioux/adverse effects [NM]	((("rofecoxib" [Substance Name]) AND ("adverse effects" [Subheading]))
TW	Append [TW]	anorexia nervosa [TW]	(anorexia nervosa [TW])
TI	Append [TI]	medical informatics [TI]	(medical informatics [TI])
TA	Append [TA]	cancer [TA]	((("Nat Rev Cancer" [Journal]) OR ("Cancer" [Journal])) OR ("BMC Cancer" [Journal]))
UI	Append [UID]	15784661 [UI]	(15784661 [UID])

MeSH processing	No SH: LC(Echo) With SH: Separate entry for each subheading with OR operator, SubheadingLookup
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Database	NLM Catalog
Backend	Entrez APIs
Sorting Order	Insert time

Search Tag	Program Action	User Input	Translation
AU	Append [AU]	Lindberg DA [AU]	(Lindberg DA [AU])
IS	Insert dash after 4th character if missing, append [TA]	0140-6736 [IS] OR 1474547X [IS]	((0140-6736 [TA]) OR (1474-547X [TA]))
LA	LanguageLookup, append [LA]	armenian [la]	("Armenian" [Language])
MH	MeSH processing, append [MH]	medical school [MH]	("schools, medical" [MeSH Terms])
MJ	MeSH processing, append [MAJR]	lymphedema [MJ] AND leg [MJ]	((("lymphedema" [MeSH Major Topic]) AND ("leg" [MeSH Major Topic]))
MH:noexp	MeSH processing, append [MH:noexp]	heart disease/diagnosis [MH:noexp]	("heart diseases/diagnosis" [MESH:noexp])
MJ:noexp	MeSH processing, append [MAJR:noexp]	neoplasms/therapy [MJ:noexp]	("neoplasms/therapy" [MAJR:noexp])
MH:nomap	MeSH processing, quote term, append [MH]	depression [MH:nomap]	("depression" [MeSH Terms])
MJ:nomap	MeSH processing, quote term, append [MAJR]	blood pressure [MJ:nomap]	("blood pressure" [MeSH Major Topic])
MH:noexp:nomap	MeSH processing, quote term, append [MH:noexp]	cold [MH:noexp:nomap]	("cold" [MeSH Terms:noexp])
MJ:noexp:nomap	MeSH processing, quote term, append [MAJR:noexp]	temperature [MJ:noexp:nomap]	("temperature" [MeSH Major Topic:noexp])
DP	Append [DP]	2006:2006 [DP]	((2006 [PublicationYear]) : (2006 [PublicationYear]))
PT	Append [PT]	textbooks [PT]	(textbooks [PT])
SH	SubheadingLookup, append [SH]	poisoning [SH]	("poisoning" [Subheading])
SU	Quoted: remove quotes, Echo unquoted: phrase detection, insert boolean AND between phrases, Echo	stroke	((("cerebrovascular accident" [All Fields]) OR ("cerebrovascular accident" [MeSH Terms])) OR (stroke [All Fields]))
SB	NA	bioethics [SB]	drop SB from search OR not applicable message
NM	SubstanceNameLookup, append [All Fields]; if subheading attached, SubheadingLookup, append "AND subheading [SH]"	viagra/therapeutic use [NM]	((("sildenafil" [All Fields]) OR (sildenafil [All Fields])) AND ("therapeutic use" [Subheading]))
TW	Append [All Fields]	medicine [TW] AND miracles [TW]	((("medicine" [MeSH Terms]) OR (medicine [All Fields])) AND (miracles [All Fields]))
TI	Append [TI]	bioinformatics [TI]	(bioinformatics [TI])
TA	Append [TA]	jama [TA]	(jama [TA])
UI	Append [NLMID]	101154385 [UI]	(101154385 [NLMID])

MeSH processing	No SH: LC(Echo) With SH: Separate entry for each subheading with OR operator, SubheadingLookup
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Database	TOXLINE Special
Backend	TOXNET
Sorting Order	Random

Search Tag	Program Action	User Input	Translation
AU	Insert @au	Stone BF [au]	(@au "stone bf")
IS	NA	0140-6736 [IS]	drop IS from search OR not applicable message
LA	LanguageLookup, insert @la	french [LA]	(@la fre)
MH	MeSH processing	depression/therapy [MH]	(@mh depression or @mh "depressive disorder")
MJ	MeSH processing	macular degeneration [MJ]	(@mh "macular degeneration")
MH:noexp	MeSH processing	lung diseases/surgery [MH:noexp]	(@mh "lung diseases")
MJ:noexp	MeSH processing	diabetes mellitus/etiology [MJ:noexp]	(@mh "diabetes mellitus")
MH:nomap	MeSH processing, no UMLS mapping	depression [MH:nomap]	(@mh depression)
MJ:nomap	MeSH processing, no UMLS mapping	blood pressure [MJ:nomap]	(@mh blood pressure)
MH:noexp:nomap	MeSH processing, no UMLS mapping	cold [MH:noexp:nomap]	(@mh cold)
MJ:noexp:nomap	MeSH processing, no UMLS mapping	immunosuppression [MJ:nomap:noexp]	(@mh immunosuppression)
DP	Insert @range yr start year end year	2002:2004 [DP]	(@range yr 2002 2004)
PT	NA	review [PT]	drop PT from search OR not applicable message
SH	SubheadingLookup, insert @mh	adverse effects [SH] OR cn [SH]	((@mh adverse effects) or (@mh congenital))
SU	Insert @all	aspirin poisoning	((@all aspirin) and (@all poisoning))
SB	NA	bioethics [SB]	drop SB from search OR not applicable message
NM	SubstanceNameLookup, insert @all; drop any subheadings	viagra [NM]	(@all sildenafil)
TW	Insert @all	hazmat [TW]	(@all hazmat)
TI	Insert @na	emergency responders [TI]	(@na "emergency responders")
TA	NA	n engl j med [TA]	drop TA from search OR not applicable message
UI	Insert @term DOCNO; append @	CRISP/2003/ES012127-02 [UI]	(@term @DOCNO CRISP/2003/ES012127-02 @)

MeSH processing	MeSHLookup, insert @mh; any subheadings discarded
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Database	Meeting Abstracts
Backend	Verity
Sorting Order	Relevance

Search Tag	Program Action	User Input	Translation
AU	Parse; (LC(last name) <EXACT><IN> LNAME AND LC(initials) <IN> INITIALS) <IN> AUTHOR	Allen NS [AU]	(("allen" <EXACT> <IN> LNAME AND "ns" <IN> INITIALS) <IN> AUTHOR)
IS	Remove dash if present; LC(Echo) <IN> INTL_STAND_SER_NO	0095-6562 [IS]	(0095 6562 <IN> INTL_STAND_SER_NO)
LA	LanguageLookup <IN> LANGUAGE	spanish [LA]	("spa" <IN> LANGUAGE)
MH	MeSH processing	gravity perception [MH]	(("gravity perception" <EXACT> <IN> KEYWORD_LIST))
MJ	MeSH processing	gravitation [MJ]	(("gravitation" <EXACT> <IN> KEYWORD_LIST))
MH:noexp	MeSH processing	plant roots/genetics/metabolism [MH:noexp]	((("plant roots" <EXACT> <IN> KEYWORD_LIST) AND ("genetics" <EXACT> <IN> KEYWORD_LIST OR "metabolism" <EXACT> <IN> KEYWORD_LIST))
MJ:noexp	MeSH processing	hypogravity [MJ:noexp]	(("hypogravity" <EXACT> <IN> KEYWORD_LIST))
MH:nomap	MeSH processing, no UMLS mapping	surgery [MH:nomap]	(("surgery" <EXACT> <IN> KEYWORD_LIST))
MJ:nomap	MeSH processing, no UMLS mapping	depression [MJ:nomap]	(("depression" <EXACT> <IN> KEYWORD_LIST))
MH:noexp:nomap	MeSH processing, no UMLS mapping	temperature [MJ:noexp:nomap]	(("temperature" <EXACT> <IN> KEYWORD_LIST))
MJ:noexp:nomap	MeSH processing, no UMLS mapping	immunosuppression [MJ:noexp:nomap]	(("immunosuppression" <EXACT> <IN> KEYWORD_LIST))
DP	Separate out each year of range and append with <IN> PUBLICATION_YEAR	2003:2005 [DP]	(2003 <IN> PUBLICATION_YEAR OR 2004 <IN> PUBLICATION_YEAR OR 2005 <IN> PUBLICATION_YEAR)
PT	LC(Echo) <IN> PUBLICATION_TYPE	journal article [PT]	("journal article" <IN> PUBLICATION_TYPE)
SH	Split subheadings if slash, SubheadingLookup <EXACT><IN> KEYWORD_LIST	tu [SH]	("therapeutic use" <EXACT> <IN> KEYWORD_LIST)
SU	Phrase detection LC(Echo) <IN> TITLE OR LC(Echo) <IN> ABSTRACT OR LC(Echo) <IN> KEYWORD_LIST OR MeshLookup <EXACT><IN> KEYWORD_LIST OR SubstanceNameLookup <EXACT> <IN> KEYWORD_LIST OR LC(Echo) <IN> SPACE_FLIGHT_MISSION	kaposi sarcoma children	((("kaposi sarcoma" <IN> TITLE OR "kaposi sarcoma" <IN> ABSTRACT OR "kaposi sarcoma" <IN> SPACE_FLIGHT_MISSION OR "kaposi sarcoma" <IN> KEYWORD_LIST OR ("sarcoma kaposi" <EXACT> <IN> KEYWORD_LIST) AND ("child" <EXACT> <IN> KEYWORD_LIST) OR "children" <IN> TITLE OR "children" <IN> ABSTRACT OR "children" <IN> SPACE_FLIGHT_MISSION OR "children" <IN> KEYWORD_LIST))
SB	SubsetLookup <IN> Citation Subset	space [SB]	("S" <IN> CitationSubset)
NM	SubstanceNameLookup <EXACT> <IN> KEYWORD_LIST; if subheading attached, SubheadingLookup, append "AND subheading <EXACT><IN> KEYWORD_LIST"	serotonin [NM]	(("serotonin" <EXACT> <IN> KEYWORD_LIST))
TW	LC(Echo) <IN> TITLE OR LC(Echo) <IN> ABSTRACT OR LC(Echo) <IN> KEYWORD_LIST OR (LC(Echo) <IN> SPACE_FLIGHT_MISSION	sts [TW]	("sts" <IN> TITLE OR "sts" <IN> KEYWORD_LIST OR "sts" <IN> ABSTRACT OR "sts" <IN> SPACE_FLIGHT_MISSION)
TI	LC(Echo) <IN> TITLE	microgravity [TI]	("microgravity" <IN> TITLE)
TA	LC(Echo) <EXACT><IN> TITLE_ABBREVIATION	gravit space biol bull [TA]	("gravit space biol bull" <EXACT> <IN> TITLE_ABBREVIATION)
UI	LC(Echo) <IN> UID	GWAIDS0040644 [UI]	(GWAIDS0040644 <IN> UID)

MeSH processing	No SH: MeshLookup, remove imbedded parentheses, append <EXACT><IN> KEYWORD_LIST With SH: SubheadingLookup, append "subheading <EXACT><IN> KEYWORD_LIST"
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Database	MedlinePlus
Backend	API
Sorting Order	Relevance

Search Tag	Program Action	User Input	Translation
AU	NA	Lindberg DA [AU]	drop AU from search OR not applicable message
IS	NA	0140-6736 [IS]	drop IS from search OR not applicable message
LA	NA	spanish [LA]	drop LA from search OR not applicable message
MH	MeSH processing	cold [MH]	(cold OR common cold OR pulmonary disease chronic obstructive)
MJ	MeSH processing	anthrax/therapy [MJ]	(anthrax)
MH:noexp	MeSH processing	macular degeneration [MH:noexp]	(macular degeneration)
MJ:noexp	MeSH processing	breast cancer/diagnosis [MJ:noexp]	(breast neoplasms)
MH:nomap	MeSH processing, no UMLS mapping	blood pressure [MH:nomap]	(blood pressure)
MJ:nomap	MeSH processing, no UMLS mapping	temperature [MJ:nomap]	(temperature)
MH:noexp:nomap	MeSH processing, no UMLS mapping	cold [MH:nomap:noexp]	(cold)
MJ:noexp:nomap	MeSH processing, no UMLS mapping	immunosuppression [MJ:nomap:noexp]	(immunosuppression)
DP	NA	2004:2005 [DP]	drop DP from search OR not applicable message
PT	NA	review [PT]	drop PT from search OR not applicable message
SH	SubheadingLookup; LC(Echo)	su [SH] OR dh [SH]	((surgery) OR (diet therapy))
SU	Phrase detection (LC(Echo))	genital warts syphilis	((condylomata acuminata) OR (genital warts)) AND ((syphilis))
SB	NA	bioethics [SB]	drop SB from search OR not applicable message
NM	SubstanceNameLookup; drop any subheadings	viagra/adverse effects [NM]	(sildenafil)
TW	LC(Echo)	septic shock [TW]	(septic shock)
TI	LC(Echo)	low blood pressure [TI]	(low blood pressure)
TA	NA	n engl j med [TA]	drop TA from search OR not applicable message
UI	NA	10984463 [UI]	drop UI from search OR not applicable message

MeSH processing	MeshLookup; drop any subheadings
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Database	ClinicalTrials.gov
Backend	API
Sorting Order	Relevance

Search Tag	Program Action	User Input	Translation
AU	NA	Lindberg DA [AU]	drop AU from search OR not applicable message
IS	NA	0140-6736 [IS]	drop IS from search OR not applicable message
LA	NA	spanish [LA]	drop LA from search OR not applicable message
MH	MeSH processing	heart attack [MH]	myocardial infarction [CONDITION]
MJ	MeSH processing	breast cancer/therapy [MJ]	breast neoplasms [CONDITION]
MH:noexp	MeSH processing	asthma [MH:noexp]	asthma [CONDITION]
MJ:noexp	MeSH processing	schizophrenia/drug therapy [MJ:noexp]	schizophrenia [CONDITION]
MH:nomap	MeSH processing, no UMLS mapping	blood pressure [MH:nomap]	blood pressure [CONDITION]
MJ:nomap	MeSH processing, no UMLS mapping	depression [MJ:nomap]	depression [CONDITION]
MH:noexp:nomap	MeSH processing, no UMLS mapping	immunosuppression [MH:nomap:noexp]	immunosuppression [CONDITION]
MJ:noexp:nomap	MeSH processing, no UMLS mapping	temperature [MJ:noexp:nomap]	temperature [CONDITION]
DP	NA	2004:2005 [DP]	drop DP from search OR not applicable message
PT	NA	review [PT]	drop PT from search OR not applicable message
SH	SubheadingLookup [ALL-FIELDS]	transplantation [SH]	transplantation [ALL-FIELDS]
SU	Phrase detection LC(Echo)[ALL-FIELDS]	genital warts	genital warts [ALL-FIELDS]
SB	NA	bioethics [SB]	drop SB from search OR not applicable message
NM	SubstanceNameLookup [TREATMENT]; drop any subheadings	vioxx [NM]	rofecoxib [TREATMENT]
TW	Append [ALL-FIELDS]	anthrax [TW]	anthrax [ALL-FIELDS]
TI	Append [TITLES]	diet [TI]	diet [TITLES]
TA	NA	n engl j med [TA]	drop TA from search OR not applicable message
UI	Append [ID-NUMBER]	NCT00079573 [UI]	NCT00079573 [ID-NUMBER]

MeSH processing	MeshLookup [CONDITION]; drop any subheadings
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Database	DIRLINE
Backend	TOXNET
Sorting Order	Random

Search Tag	Program Action	User Input	Translation
AU	NA	Lindberg DA [AU]	drop AU from search OR not applicable message
IS	NA	0140-6736 [IS]	drop IS from search OR not applicable message
LA	NA	spanish [LA]	drop LA from search OR not applicable message
MH	MeSH processing	cystic fibrosis/therapy [MH]	(@mh cystic fibrosis)
MJ	MeSH processing	hiv [MJ]	(@mh acquired immunodeficiency syndrome or @mh hiv)
MH:noexp	MeSH processing	high blood pressure/drug therapy [MH:noexp]	(@mh hypertension)
MJ:noexp	MeSH processing	varicose veins [MJ:noexp]	(@mh varicose veins)
MH:nomap	MeSH processing, no UMLS mapping	depression [MH:nomap]	(@mh depression)
MJ:nomap	MeSH processing, no UMLS mapping	surgery [MJ:nomap]	(@mh surgery)
MH:noexp:nomap	MeSH processing, no UMLS mapping	immunosuppression [MH:nomap:noexp]	(@mh immunosuppression)
MJ:noexp:nomap	MeSH processing, no UMLS mapping	blood pressure [MJ:nomap:noexp]	(@mh blood pressure)
DP	NA	2004:2005 [DP]	drop DP from search OR not applicable message
PT	NA	review [PT]	drop PT from search OR not applicable message
SH	SubheadingLookup, insert @mh	diet therapy [SH]	(@mh diet therapy)
SU	Phrase detection SubstanceNameLookup, insert @all	breast cancer	(@all "breast cancer")
SB	NA	bioethics [SB]	drop SB from search OR not applicable message
NM	SubstanceNameLookup, insert @all; drop any subheadings	aspirin/therapeutic use [NM]	(@all aspirin)
TW	Insert @all	self help groups [TW]	(@all "self help groups")
TI	Insert @na	diet [TI]	(@na diet)
TA	NA	n engl j med [TA]	drop TA from search OR not applicable message
UI	Insert @term DOCNO LC, append @and	HSRI/1138 [UI]	(@term @DOCNO HSRI/1138 @and)

MeSH processing	MeshLookup, insert @mh; any subheadings discarded
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Database	Genetics Home Reference
Backend	API
Sorting Order	Relevance

Search Tag	Program Action	User Input	Translation
AU	NA	Lindberg DA [AU]	drop AU from search OR not applicable message
IS	NA	0140-6736 [IS]	drop IS from search OR not applicable message
LA	NA	spanish [LA]	drop LA from search OR not applicable message
MH	MeSH processing	colon cancer [MH]	(colonic neoplasms)
MJ	MeSH processing	schizophrenia/drug therapy [MJ]	(schizophrenia)
MH:noexp	MeSH processing	arthritis/therapy [MH:noexp]	(arthritis)
MJ:noexp	MeSH processing	breast cancer/diagnosis [MJ:noexp]	(breast neoplasms)
MH:nomap	MeSH processing, no UMLS mapping	surgery [MH:nomap]	(surgery)
MJ:nomap	MeSH processing, no UMLS mapping	temperature [MJ:nomap]	(temperature)
MH:noexp:nomap	MeSH processing, no UMLS mapping	cold [MH:noexp:nomap]	(cold)
MJ:noexp:nomap	MeSH processing, no UMLS mapping	blood pressure [MH:nomap:noexp]	(blood pressure)
DP	NA	2004:2005 [DP]	drop DP from search OR not applicable message
PT	NA	review [PT]	drop PT from search OR not applicable message
SH	SubheadingLookup; LC(echo)	congenital [SH]	(congenital)
SU	Phrase detection (LC(Echo))	alzheimer's disease	((alzheimer disease) OR (alzheimer's disease))
SB	NA	bioethics [SB]	drop SB from search OR not applicable message
NM	SubstanceNameLookup; drop any subheadings	benzene/adverse effects [NM]	(benzene)
TW	LC(Echo)	depression [TW]	(depression)
TI	LC(Echo)	lynch syndrome [TI]	(lynch syndrome)
TA	NA	n engl j med [TA]	drop TA from search OR not applicable message
UI	NA	10984463 [UI]	drop UI from search OR not applicable message

MeSH processing	MeSHLookup; any subheadings discarded
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Database	HSRProj
Backend	Verity
Sorting Order	Relevance

Search Tag	Program Action	User Input	Translation
AU	Parse; (LC(last name) <EXACT><IN> LastName AND LC(initials) <IN> Initials) <IN> Investigator	Smith DH [AU]	(("smith" <EXACT> <IN> LastName AND "dh" <IN> Initials) <IN> Investigator)
IS	NA	0140-6736 [IS]	drop IS from search OR not applicable message
LA	NA	spanish [LA]	drop LA from search OR not applicable message
MH	MeSH processing	cost-benefit analysis [MH] AND asthma/therapy [MH]	((("cost benefit analysis" <EXACT> <IN> DescriptorName <IN> MeshHeading) AND (("asthma" <EXACT> <IN> DescriptorName AND ("therapy" <EXACT> <IN> QualifierName)) <IN> MeshHeading))
MJ	Major MeSH processing	health services research [MJ]	("health services research" <EXACT> <IN> DescriptorName <WHEN> MajorTopicYN = y <IN> MeshHeading)
MH:noexp	MeSH processing	social security [MH:noexp]	("social security" <EXACT> <IN> DescriptorName <IN> MeshHeading)
MJ:noexp	Major MeSH processing	medicare/standards [MJ:noexp]	((("medicare" <EXACT> <IN> DescriptorName <WHEN> MajorTopicYN = y AND ("standards" <EXACT> <IN> QualifierName))) OR (("medicare" <EXACT> <IN> DescriptorName AND ("standards" <EXACT> <IN> QualifierName <WHEN> MajorTopicYN = y))) <IN> MeshHeading)
MH:nomap	MeSH processing, no UMLS mapping	surgery [MH:nomap]	("surgery" <EXACT> <IN> DescriptorName <IN> MeshHeading)
MJ:nomap	Major MeSH processing, no UMLS mapping	depression [MJ:nomap]	("depression" <EXACT> <IN> DescriptorName <WHEN> MajorTopicYN = y <IN> MeshHeading)
MH:noexp:nomap	MeSH processing, no UMLS mapping	blood pressure[MH:nomap:noexp]	("blood pressure" <EXACT> <IN> DescriptorName <IN> MeshHeading)
MJ:noexp:nomap	Major MeSH processing, no UMLS mapping	blood pressure [MJ:nomap:noexp]	("blood pressure" <EXACT> <IN> DescriptorName <WHEN> MajorTopicYN = y <IN> MeshHeading)
DP	Separate out each year of range and search <IN> ALL_YEARS	2007:2010 [DP]	(2007 <IN> ALL_YEARS OR 2008 <IN> ALL_YEARS OR 2009 <IN> ALL_YEARS OR 2010 <IN> ALL_YEARS)
PT	NA	review [PT]	drop PT from search OR not applicable message
SH	Split subheadings if slash, SubheadingLookup <EXACT><IN> QualifierName	ut [SH]	("utilization" <EXACT> <IN> QualifierName)
SU	(LC(Echo) <IN> ProjectTitle OR LC(Echo) <IN> AbstractText OR LC(Echo) <IN> MeshHeading OR LC(Echo) <IN> KeywordList OR LC(Echo) <IN> State OR LC(Echo) <IN> SupportingAgency OR LC(Echo) <IN> PerformingOrganization OR MeshLookup <EXACT><IN> DescriptorName <IN> MeshHeading OR SubstanceNameLookup <IN> ProjectTitle OR SubstanceNameLookup <IN> AbstractText OR SubstanceNameLookup <EXACT> <IN> DescriptorName <IN> MeshHeading OR SubstanceNameLookup <IN> KeywordList)	anorexia nervosa	("anorexia nervosa" <IN> SupportingAgency OR "anorexia nervosa" <IN> KeywordList OR "anorexia nervosa" <EXACT> <IN> DescriptorName <IN> MeshHeading OR "anorexia nervosa" <IN> MeshHeading OR "anorexia nervosa" <IN> PerformingOrganization OR "anorexia nervosa" <IN> State OR "anorexia nervosa" <IN> AbstractText OR "anorexia nervosa" <IN> ProjectTitle)
SB	NA	bioethics [SB]	drop SB from search OR not applicable message
NM	SubstanceNameLookup <IN> ProjectTitle OR SubstanceNameLookup <IN> AbstractText OR SubstanceNameLookup <EXACT> <IN> Descriptor <IN> MeshHeading OR SubstanceNameLookup <IN> KeywordList; if subheading attached, SubheadingLookup, add "AND subheading <EXACT><IN> QualifierName"	aspirin/adverse effects [NM]	((("aspirin" <IN> AbstractText OR aspirin <IN> KeywordList OR "aspirin" <EXACT> <IN> MeshHeading OR aspirin <IN> ProjectTitle) AND ("adverse effects" <EXACT> <IN> QualifierName)))
TW	LC(Echo) <IN> ProjectTitle OR LC(Echo) <IN> AbstractText OR LC(Echo) <IN> MeshHeading OR LC(Echo) <IN> KeywordList OR LC(Echo) <IN> State OR LC(Echo) <IN> SupportingAgency OR LC(Echo) <IN> PerformingOrganization	agency for health care policy and research [TW]	("agency for health care policy and research" <IN> ProjectTitle OR "agency for health care policy and research" <IN> AbstractText OR "agency for health care policy and research" <IN> KeywordList OR "agency for health care policy and research" <IN> PerformingOrganization OR "agency for health care policy and research" <IN> SupportingAgency OR "agency for health care policy and research" <IN> State)
TI	LC(Echo) <IN> ProjectTitle	cost effectiveness [TI]	("cost effectiveness" <IN> ProjectTitle)
TA	NA	n engl j med [TA]	drop TA from search OR not applicable message
UI	LC(Echo) <IN> ProjectID	HSRP20044208 [UI]	(HSRP20044208 <IN> ProjectID)
MeSH processing	No SH: MeshLookup <EXACT><IN> DescriptorName <IN> MeshHeading With SH: MeshLookup <EXACT><IN> DescriptorName AND (SubheadingLookup <EXACT> <IN> QualifierName) <IN> MeshHeading	Major MeSH processing	No SH: MeshLookup <EXACT><IN> DescriptorName <WHEN> MajorTopicYN = y <IN> MeshHeading With SH: (MeshLookup <EXACT><IN> DescriptorName <WHEN> MajorTopicYN = y AND (SubheadingLookup <EXACT> <IN> QualifierName)) OR (MeshLookup <EXACT><IN> DescriptorName AND (SubheadingLookup <EXACT> <IN> QualifierName <WHEN> MajorTopicYN = y)) <IN> MeshHeading

Database	OMIM
Backend	Entrez APIs
Sorting Order	Relevance

Search Tag	Program Action	User Input	Translation
AU	Append [AU]	Smith M [AU]	(Smith M [AU])
IS	NA	0140-6736 [IS]	drop IS from search OR not applicable message
LA	NA	spanish [LA]	drop LA from search OR not applicable message
MH	MeSH processing	lynch syndrome/diagnosis [MH]	(((((colorectal [All Fields]) AND (neoplasms [All Fields])) AND (, hereditary [All Fields])) AND (nonpolyposis [All Fields])) AND (diagnosis [All Fields]))
MJ	MeSH processing	macular degeneration [MJ]	((macular [All Fields]) AND (degeneration [All Fields]))
MH:noexp	MeSH processing	prostate cancer/surgery [MH:noexp]	((surgery [All Fields]) AND ((prostatic [All Fields]) AND (neoplasms [All Fields])))
MJ:noexp	MeSH processing	stroke/etiology [MJ:noexp]	((etiology [All Fields]) AND ((cerebrovascular [All Fields]) AND (accident [All Fields])))
MH:nomap	MeSH processing, no UMLS mapping	immunosuppression [MH:nomap]	(immunosuppression [All Fields])
MJ:nomap	MeSH processing, no UMLS mapping	surgery [MJ:nomap]	(surgery [All Fields])
MH:noexp:nomap	MeSH processing, no UMLS mapping	temperature [MH:nomap:noexp]	(temperature [All Fields])
MJ:noexp:nomap	MeSH processing, no UMLS mapping	blood pressure [MJ:nomap:noexp]	((blood [All Fields]) AND (pressure [All Fields]))
DP	NA	2004:2005 [DP]	drop DP from search OR not applicable message
PT	NA	review [PT]	drop PT from search OR not applicable message
SH	SubheadingLookup; Append [All Fields]	etiology [SH]	(etiology [All Fields])
SU	LC(Echo)	alzhiemer's disease	((alzheimer's [All Fields]) AND (disease [All Fields]))
SB	NA	bioethics [SB]	drop SB from search OR not applicable message
NM	SubstanceNameLookup, append [All Fields]; drop any subheadings	vioxx [NM]	(rofecoxib [All Fields])
TW	Append [TXT]	cancer gene [TW]	(cancer gene [TXT])
TI	Append [TI]	brca1 [TI]	(brca1 [TI])
TA	NA	n engl j med [TA]	drop TA from search OR not applicable message
UI	Append [ID]	114500 [UI]	(114500 [ID])

MeSH processing	No SH: MeSHLookup [All Fields] With SH: AND SubheadingLookup [All Fields]
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Database	HSDB
Backend	TOXNET
Sorting Order	Random

Search Tag	Program Action	User Input	Translation
AU	NA	Lindberg DA [AU]	drop AU from search OR not applicable message
IS	NA	0140-6736 [IS]	drop IS from search OR not applicable message
LA	NA	spanish [LA]	drop LA from search OR not applicable message
MH	MeSH processing	ammonia/adverse effects [MH]	(@all ammonia)
MJ	MeSH processing	potassium chloride [MJ]	(@all potassium chloride)
MH:noexp	MeSH processing	arthritis/therapy [MH:noexp]	(@all arthritis)
MJ:noexp	MeSH processing	asthma/etiology [MJ:noexp]	(@all asthma)
MH:nomap	MeSH processing, no UMLS mapping	cold [MH:nomap]	(@all cold)
MJ:nomap	MeSH processing, no UMLS mapping	depression [MJ:nomap]	(@all depression)
MH:noexp:nomap	MeSH processing, no UMLS mapping	immunosuppression [MH:nomap:noexp]	(@all immunosuppression)
MJ:noexp:nomap	MeSH processing, no UMLS mapping	blood pressure [MJ:nomap:noexp]	(@all blood pressure)
DP	NA	2004:2005 [DP]	drop DP from search OR not applicable message
PT	NA	review [PT]	drop PT from search OR not applicable message
SH	SubheadingLookup, insert @all	poisoning [SH]	(@all poisoning)
SU	Phrase detection, SubstanceNameLookup, insert @all	celebrex	(@all celebrex or @all celecoxib)
SB	NA	bioethics [SB]	drop SB from search OR not applicable message
NM	SubstanceNameLookup, insert @all; drop any subheadings	viagra/adverse effects [NM]	(@all sildenafil)
TW	Insert @all	anthrax [TW]	(@all anthrax)
TI	Insert @na	smallpox [TI]	(@na smallpox)
TA	NA	n engl j med [TA]	drop TA from search OR not applicable message
UI	NA	10984463 [UI]	drop UI from search OR not applicable message

MeSH processing	MeSHLookup, insert @all; drop any subheadings
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