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A compilation of molecular biology web servers: 2006 update on the Bioinformatics Links Directory

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ABSTRACT

The Bioinformatics Links Directory is a public online resource that lists the servers published in this and all previously published *Nucleic Acids Research* Web Server issues together with other useful tools, databases and resources for bioinformatics and molecular biology research. This rich directory of tools and websites can be browsed and searched with all listed links freely accessible to the public. The 2006 update includes the 149 websites highlighted in the July 2006 issue of *Nucleic Acids Research* and brings the total number of servers listed in the Bioinformatics Links Directory to over 1000 links. To aid navigation through this growing resource, all link entries contain a brief synopsis, a citation list and are classified by function in descriptive biological categories. The most up-to-date version of this actively maintained listing of bioinformatics resources is available at the Bioinformatics Links Directory website, http://bioinformatics.ubc.ca/resources/links_directory/. A complete list of all links listed in this *Nucleic Acids Research* 2006 Web Server issue can be accessed online at http://bioinformatics.ubc.ca/resources/links_directory/narweb2006/. The 2006 update of the Bioinformatics Links Directory, which includes the Web Server list and summaries, is also available online at the *Nucleic Acids Research* website, http://nar.oupjournals.org/.

COMMENTARY

In this era of information and technology, modern scientists must take advantage of cutting-edge data analysis software packages, search the most up-to-date versions of biological databases and use the very latest research resources. As a first step, many researchers head to their favorite search engine on the internet to search for their service of choice only to become lost in a myriad of irrelevant links. For example, if you search for 'bioinformatics servers' using Google, you will face the daunting task of sorting through almost a million different websites. In an effort to provide clarity, *Nucleic Acids Researc*h has devoted several special issues to compiling molecular biology Web Servers (1) and Databases (2) helping researchers to quickly locate peer-reviewed tools and resources that directly apply to the changing bioinformatics landscape. Over the past 4 years, the NAR Web Server special issue has published a rich collection of over 500 different internet-based resources. This year, the 2006 Web Server issue highlights 149 bioinformatics and molecular biology servers that are all openly available to the world-wide research community. A complete listing of servers from the 2006 Web Server issue can be accessed online at http://bioinformatics.ubc.ca/resources/links_directory/narweb2006/ and in Supplementary Table 1. Together with the long standing Database issue (2), these special issues at *Nucleic Acids Research* represent a valuable directory of resources for the global life sciences research community.

The Bioinformatics Links Directory, http://bioinformatics.ubc.ca/resources/links_directory/, is a public resource that lists the servers published in this and previous issues of *Nucleic Acids Research* Web Server issues together with other useful tools, databases and resources for bioinformatics and molecular biology research (1). This directory contains entries of individually curated web resources and links actively collected by researchers at the UBC Bioinformatics Centre from their experiences conducting bioinformatics research, navigating the Internet and teaching bioinformatics. In 2005, *Nucleic Acids Research* partnered with the Bioinformatics Links Directory to ensure that all of the links from the Web Server special issues were listed. In the Bioinformatics Links Directory, each resource is highlighted by providing a brief summary for each link, functionally classifying links in descriptive functional categories, listing relevant PubMed citations and identifying links as servers from the *Nucleic Acids Research* Web Server issue. This compilation of web-based research tools currently contains links to over 1000 different servers and databases hosted in over 35 different countries. To aid navigation through this growing resource, links are grouped by biological subject

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Table 1. Summary of the number of web servers listed in each subcategory of the Bioinformatics Links Directory

Name	URL[a]
Computer Related	
Bio-* programming tools	20
C/C++	3
Databases	2
Java	4
Linux/Unix	12
PERL	5
PHP	3
Statistics	9
Web development	6
Web services	6
DNA	
Annotations	38
Gene prediction	32
Mapping and assembly	14
Phylogeny reconstruction	37
Sequence feature detection	118
Sequence polymorphisms	32
Sequence retrieval and submission	26
Tools for the bench	55
Utilities	19
Education	
Bioinformatics related news sources	9
Community	19
Courses, programs and workshops	5
Directories and portals	15
General	15
Tutorials and directed learning resources	9
Expression	
cDNA, EST, SAGE	29
Gene regulation	96
Microarrays	75
Protein expression	8
Splicing	16
Human genome	
Annotations	31
Ethics	7
Genomics	4
Health and disease	14
Other resources	25
Sequence polymorphisms	25
Literature	
Goldmines	6
Open access resources	2
Search tools	10
Text mining	11
Model organisms	
Fish	11
Fly	16
General resources	23
Microbes	31
Mouse and rat	32
Other organisms	18
Other vertebrates	10
Plants	16
Worm	9
Yeast	15
Other molecules	
Carbohydrates	6
Small molecules	3
Protein	
2D Structure prediction	51
3D Structural features	53
3D Structure comparison	35
3D Structure prediction	48
3D Structure retrieval, viewing	45
Biochemical features	37
Do-it-all tools for protein	8
Domains and motifs	86
Function	35
Interactions, pathways, enzymes	66
Localization and targeting	30
Molecular dynamics and docking	19
Phylogeny reconstruction	36
Presentation and format	13
Protein expression	8
Proteomics	25
Sequence data	7
Sequence features	25
Sequence retrieval	27
RNA	
Functional RNAs	14
General Resources	10
Motifs	19
Sequence retrieval	11
Structure prediction, visualization and design	38
Sequence comparison	
Alignment editing and visualization	20
Analysis of aligned sequences	43
Comparative genomics	26
Multiple sequence alignments	38
Other alignment tools	11
Pairwise sequence alignments	22
Similarity searching	31

[a]A complete listing of all URLs listed in the *Nucleic Acids Research* 2006 Web Server Issue can be accessed online at http://bioinformatics.ubc.ca/resources/links_directory/narweb2006/.

areas (DNA, Protein, RNA, Other Molecules, Expression, Sequence Comparison, Model Organisms, Human Genome, Education, Literature and Computer Related) and are functionally classified into descriptive subcategories. Table 1 shows the number of web servers contained within each subcategory of the Bioinformatics Links Directory. Users can browse the biological categories or can search the Bioinformatics Links Directory directly with a keyword search.

The Bioinformatics Links Directory is a curated resource that is constantly being verified and updated. All links are automatically checked weekly to ensure that no broken links are presented. To help notify users of updates, syndication feeds are provided by a computer-readable file that summarizes any new information published on the Bioinformatics Links Directory website. The Bioinformatics Links Directory feeds use the popular RSS 1.0 (RDF Site Summary) format. By subscribing to the Bioinformatics Links Directory RSS feeds, you can automatically be notified of recent updates and new links added to any topic areas. To learn more about RSS feeds and how to use them on the UBC Bioinformatics website, please look at http://bioinformatics.ubc.ca/resources/links_directory/syndication.php. The 2006 update of the Bioinformatics Links Directory can also be accessed online via the Web Server summaries link at the *Nucleic Acids Research* website, http://nar.oupjournals.org/.

The scope of the research expertise presented in the 2006 Web Server special issue covers very large number of research applications. Servers from the 2006 NAR Web Server special issue are distributed into 58 of the 86 different functional subcategories contained within the Bioinformatics Links Directory. Figure 1 shows the trend of the number of servers published in the NAR Web Server issues (starting

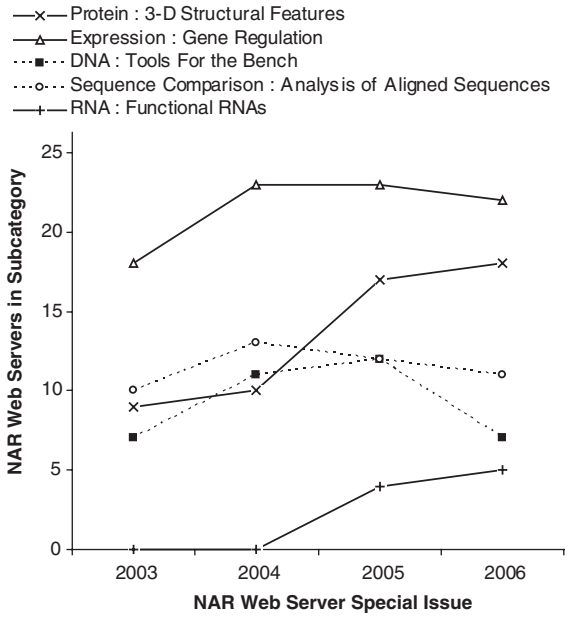

Figure 1. Number of NAR Web Servers from selected subcategories of the Bioinformatics Links Directory. Over the past 4 years, *Nucleic Acids Research* has published a special issue every July of useful molecular biology and bioinformatics servers. The Bioinformatics Links Directory (http://bioinformatics.ubc.ca/resources/links_directory/) contains a compilation of all of these web servers categorized by subject area. Shown here are the numbers of NAR web servers published from 2003–2006 for five selected subcategories of the Bioinformatics Links Directory: Protein: 3D Structural Features; Expression: Gene Regulation; DNA: Tools for the Bench; Sequence Comparison: Analysis of Aligned Sequences and RNA: Functional RNAs.

with the first Web Server issue in 2003) for five selected subject areas in the Bioinformatics Links Directory that represent some of the key subcategories in the directory. In 2006, we see an increase in the number of servers for the prediction and design of functional RNAs such as small-interfering RNAs (siRNA) and micro RNAs (miRNAs) target prediction (3). On the other hand, the number of servers for PCR-based primer design, classified under 'DNA:Tools for the Bench' has remained relatively steady. In addition to describing new tools, the NAR Web Server issue also contains publications describing updates and new developments for well established gold standards such as the Basic Local Alignment Search Tool (BLAST) (4). Another research area, which has seen a recent increase in the number of web servers, is the prediction and comparison of three-dimensional protein structural features. The 'Protein: 3-D Structural Features' subcategory of the Bioinformatics Links Directory lists a total of 53 different servers (18 from the 2006 Web Server issue). These servers offer a rich set of resources for investigating biomolecular structures, and as an example, can carry out tasks such as evaluating the structural features of potential binding regions in proteins (5).

The Bioinformatics Links Directory is an actively maintained community driven resource. Future developments to the Bioinformatics Links Directory include the implementation of advanced search options that will allow users to include the text from PubMed abstracts when searching for relevant links. We are also investigating the development of an ontology and/or meta-tags to aid in the functional classification of servers listed in this Bioinformatics Links Directory as well as others, as was recently suggested by Cannata and colleagues (6). We look forward to working with the community on this exciting development. Suggestions for additions, revisions or corrections to the Bioinformatics Links Directory are strongly encouraged. Please use the Suggest URL link found at http://bioinformatics.ubc.ca/resources/links_directory/add.php, or email your suggestions directly to info@bioinformatics.ubc.ca.

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