

established NATO Double Jump Programme designed to promote international co-operation between universities and industries in NATO countries. A similar ASI is to be held in 1991 and short courses and workshops have been organized in Europe and South East Asia. A course on animal cell-culture techniques, open to the international scientific community, is also planned by The Institute in September 1990 under the auspices of the British Council.

As a means to promoting an increased general awareness of biotechnology an Annual Medal

Lecture is held each Spring at The Royal Society in London. World-renowned scientists are invited to lecture on biotechnological issues of industrial and social relevance. They are presented with a gold medal, an award, and have the Fellowship of The Institute conferred upon them.

As a charitable company The IIB functions as an international institute without walls, such that unlike the ICGEB, which is permanently based in Trieste and New Delhi, The IIB acts to coordinate the activities of multidisciplinary, multinational groups from both industrialized and newly industrializing nations brought

together as a result of an IIB initiative to tackle a defined problem. As such the groupings will vary according to the problem being addressed, and will last as long as there is a continued need for the interaction of the combined expertise represented.

Activities and contacts developed over a number of years have resulted in an effective infrastructure and an extensive network which enables The Institute to interact at all levels with other institutions to develop new initiatives and this in turn leads to closer collaboration between scientists and engineers in the international biotechnology arena.



## An overview of biotechnology information resources

Layne M. Johnson and Ronald A. Rader

In the 1980s, the combination of recombinant DNA technology with other advances in the biological and physical sciences resulted in an explosion of scientific information in molecular, microbial and cellular biology. This necessitated the development of an infrastructure of information resources to support the expanding field of biotechnology<sup>1</sup>.

To be successful in the commercial atmosphere of biotechnology in the 1990s, familiarity with the basic resources available for obtaining up-to-the-minute information is essential.

Efficient application of biotechnology requires the integration of scientific, technological and commercial information. The transformation of scientific information into useful technologies is fundamental to biotechnology, which relies on developments in many *chemical* and

*biological* sciences (such as microbiology, biochemistry, genetics, molecular biology, toxicology, pharmacology and bioengineering), and *physical* sciences, with regard to instrumentation, equipment and data-handling facilities.

Primary information sources for biotechnology include journals, reports, newsletters and patents. Resources which facilitate retrieval or retrospective access to information, data and documents include online bibliographic, factual and numerical databases, directories, catalogs, substance and organism registries, libraries, referral centers and clearing houses. Specific biotechnology information centers exist, including the Biotechnology Information Division of the North Carolina Biotechnology Center and the Biotechnology Information Service of the British Library.

Resources vary greatly in coverage, format, ease of use, availability, cost and other parameters directly affecting their use: they are designed to specific user needs and usually presume varying levels of infor-

mation and subject expertise. Today, the work of information users and gatherers (biotechnologists and information scientists), is often closely intertwined<sup>2</sup>. In some areas, biotechnology professionals whose work is information intensive have formed local user groups, such as the Capital Area Biotechnology Information Network (CABIN) in Washington, DC.

A variety of directories are available to assist in identifying relevant sources of information. *Information Sources in Biotechnology* is probably the most comprehensive published review of such data<sup>3</sup>. *The Directory of Biotechnology Information Resources* (DBIR) an online database available on the National Library of Medicine system, lists databases, database networks, biotechnology organizations, publications and nomenclature committees. *Biotechnology Information News* (published four times a year by the British Library Biotechnology Information Service), reports news and developments in biotechnology information. The British Library is also publishing *Introduction to Biotechnology Information* (ISBN 0 71230 762 1), which will be available soon.

Since much of biotechnology research is targeted towards medical and pharmaceutical applications, directories in these areas are also of value, including *Guide to Drug Information* (Drug Intelligence Publications, Hamilton, IL) and *Information Sources in the Medical Sciences*

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**Table 1***Some Biotechnology company, organization and information directories*

Title and date	Details
<i>Australian and New Zealand Biotechnology Directory</i> (1989)	Australian Industrial Publishers, Pty. Ltd, Underdale, Australia
<i>Bio1000™</i> (1990)	Deborah J. Mysiewicz Publishers Inc., Port Angeles, WA
<i>BioScan. The Biotechnology Corporate Director Service</i> (1990)	The Oryx Press, Phoenix, AZ
<i>Biotechnology Guide Japan, 1990–1991</i> (1990)	Nikkei Biotechnology, Inc., Stockton Press, New York, NY
<i>Biotechnology Guide USA Companies, Data and Analysis</i> (1988)	Dibner, M. D., Stockton Press, New York, NY
<i>Biotechnology Japan</i> (1989)	Dibner, M. D. and White, R. S., McGraw-Hill, New York, NY
<i>Biotechnology Regulations: Environmental Release Compendium</i> (1988)	OMEC International, Inc., Washington, DC
<i>Biotechnology Regulations Handbook</i> (1990)	E. L. Korwek, Center for Energy and Environmental Management, Fairfax Station, VA
<i>Canadian Biotechnology Industry Sourcebook</i> (1988)	Weldon, J. and Shindler, D. B., Ministry of State for Science and Technology, Ottawa, Ontario
<i>Directory of States' Biotechnology Centers</i> (1988)	North Carolina Biotechnology Center
<i>Encyclopedia of Organizations</i> (1990)	Gale Research, Detroit, MI
<i>Federal Biotechnology Information Resources Directory</i> (1987)	OMEC International, Inc., Washington, DC
<i>Federal Biotechnology Programs Directory</i> (1987)	OMEC International, Inc., Washington, DC
<i>Genetic Engineering News (GEN) Guide To Biotechnology Companies</i> (1989)	Mary Ann Liebert, Inc., Publishers, New York, NY
<i>Pharmaprojects</i> (1990)	PJB Publications, Ltd., Richmond, UK
<i>The Biotechnology Directory. Products, Companies, Research, and Organizations</i> (1990)	Coombs, J. and Alston, Y. R., Stockton Press, New York, NY
<i>The UK Biotechnology Handbook '90</i> (1990)	Crafts-Lighty, A., Reed, E. B. and Lanning, S., BioCommerce Data Ltd, Slough, UK

(Butterworths, London, UK). Analyses of the drug industry are published annually in *Scrip's Yearbook* (PJB Publications, Ltd, Richmond, UK) and *Dun's® Guide to Healthcare Companies 1989/90* (Dun's Marketing Services, Inc., Parsippany, NJ) provides commercially relevant information.

### Biotechnology information resources

Among the most useful biotechnology resources are public and private libraries. While many large companies have their own special libraries and information centers, local university and medical libraries can support many needs, including

document delivery, for small biotechnology companies. Using the expertise of an information scientist or technical librarian may often be the quickest and most cost-effective means for obtaining information. Most libraries and information centers offer, or can assist with obtaining online database searches, assist in using in-house research resources, and can provide valuable referrals.

Many organizations, clearing houses, government agencies, referral and information centers provide information at no cost. Trade and professional organizations, such as the Industrial Biotechnology Association, Association of Biotechnology Companies, Pharmaceutical Manufacturers Association and other groups often provide the best available information, since it comes directly from experts or specialized information resources. Some directories of US federal resources and programs, trade and professional and other organizations and information clearing houses are listed in Table 1.

For many, the hundreds of readily available databases and corresponding publications which abstract and index the literature are the most convenient information resources (Table 2). Libraries and database directories, such as the *Directory of Online Databases* (Cuadra/Elsevier, New York), can assist in identifying and assessing relevant databases for a particular application. A comparison of online databases containing biotechnology information and advice for choosing online vendors has been produced<sup>4</sup>.

Information requirements of the research scientist at the bench differ slightly. Many routinely need to identify sources and characteristics of a multitude of microbial strains and cell lines. However, hundreds of sources of biological materials exist worldwide. In the past, information describing these materials was found primarily in catalogs of culture collections and research reagents. Such references are still invaluable, and many are now accessible as online databases. Microbial and cell line information resources have been summarized by Bower<sup>5</sup> and other useful resources have been reviewed by Wakeford<sup>6</sup>.

*The Microbial Strain Data Network* (MSDN, Cambridge, UK) is an

**Table 2***Some abstracting and indexing online databases*

Name and details	Comment on content
<b>BIOBUSINESS®</b> Producer: BioScience Information Service Vendors: B, BC, D, DS <sup>a</sup>	Provides both business and research information. Includes US patents from 1986, and covers biotechnology newsletters, meeting abstracts and journals since 1985.
<b>Abstracts in BioCommerce</b> Producer: BioCommerce Data Ltd. Vendors: D, DS	Covers biotechnology business information, especially newsletters. Records often list multiple sources for each abstract. Includes directory and descriptions of over 900 biotechnology companies.
<b>BIOETHICSLINE®</b> Producer: National Library of Medicine, and The Kennedy Institute of Bioethics Vendors: B, BC, D, DM, DS, S	Biomedical ethics as they pertain to genetic engineering and related disciplines. Approximately 30 000 records.
<b>BioMeetings</b> Producer: BioSciences Information Service Vendors: BCON	Includes more than 130 000 references to life science research reported at meetings or published in books or journals. Coverage is international and includes reports from scientific meetings, symposia, seminars and conferences.
<b>BioPatents</b> Producer: BioSciences Information Service Vendors: BCON	Contains about 9000 patents granted in the USA in specialized life science fields since November 1987.
<b>BIOREP</b> Producer: Royal Netherlands Academy of Arts and Sciences Vendor: ECHO Service	Contains descriptions of about 6000 biotechnology research projects in the European Economic Community (EEC) countries. Corresponds to <i>Biorep. Newsletter</i> and is updated with about 1000 records each year.
<b>BIOSIS PREVIEWS®</b> (Biological Abstracts) Producer: BioSciences Information Service Vendors: B, BC, D, DM, DS, S	Covers conference proceedings, reviews, books, US patents and the periodical literature. Six million records from 1969 to present. Includes sequence accession numbers.
<b>Biotechnology Abstracts</b> Producer: Derwent Publications Vendors: D, O	Covers periodical literature and patents. More than 75 000 records from June 1982 to present. (About 27% are patents.)
<b>CA Search®</b> (Chemical Abstracts) Producer: Chemical Abstracts Service Vendors: B, BC, D, DM, S	Journal articles, reviews, conference and symposium proceedings, and patents from several worldwide sources. Over eight million records.
<b>CAB ABSTRACTS</b> Producer: Commonwealth Agriculture Bureaux Vendors: B, BC, D, DM	Covers agriculture, including agricultural biotechnology.
<b>CLAIMS™/US PATENTS</b> Producer: IFL/Plenum Data Company Vendor: D, O, S	US patent coverage from 1950 to present. Over 1.7 million patents accessible.

online directory, accessible via DIALCOM and TELECOM GOLD, allowing access to strain information held in collections worldwide<sup>7,8</sup>. It includes descriptions and references to sources of bacteria, yeasts, actinomycetes, filamentous fungi and algae, as well as vectors, hybridomas and animal cell lines. Major sources of strain information that can be found in MSDN include the *American Type Culture Collection* (ATCC, Rockville, MD), *Microbial Culture Information System* (MiCIS, Braunschweig, FRG) and *Microbial Information Network*

*Europe* (MINE, Surrey, UK). *The Taxonomic Reference File* (TRF) developed by BioSciences Information Service (BIOSIS, Philadelphia, PA) includes bacterial names and synonyms for most bacteria and a bibliographic file of more than 13 500 bacterial taxonomy references published since 1969.

Nucleotide and peptide sequence databases, references to sequence source, and sequence analysis software are valuable tools. It has been projected that, by 2001, the amount of sequence data deposited on a

weekly basis will more than equal the number of bases deposited in the entire history of the largest genetic sequence database, GenBank<sup>9</sup>. Sequence analysis software packages allow researchers to compare unknown sequences from their work with those that are published. Many databases and corresponding software are available in a variety of formats (e.g. CD-ROM, floppy disks, online via a number of networks, hardcopy). The *Listing of Molecular Biology Databases* (Los Alamos National Laboratory, Los Alamos,

Name and details	Comment on content
<b>Current Biotechnology Abstracts</b> Producer: Royal Society of Chemistry Vendors: D, DS	Commercial news, scientific and technical literature, forthcoming events, book announcements and conference proceedings. More than 12 000 citations, from 1983 to present, including European, US, PCT and UK patents.
<b>EMBASE™</b> Producer: Excerpta Medica Vendors: D, BC, DS, D, DM	Covers biomedical periodical literature. Contains almost 4.5 million references, many from non-English journals and sources not covered elsewhere.
<b>European Patents Register (EPAT)</b> Producer: (INPI) Institut National de la Propriete Industrielle Vendor: Q	Covers European patent disclosures and patent status information. Patents since mid-1978 (>275 000 records). Very timely (updated weekly) EP patents.
<b>Federal Research in Progress</b> Producer: National Technical Information Service Vendor: D	Describes research in progress and recently completed projects sponsored by US government agencies.
<b>Life Sciences Collection</b> Producer: Cambridge Scientific Abstracts Vendors: B, BC, D	A collection of databases, including Microbiology Abstracts, Biotechnology Research Abstracts, and patents granted in the USA and UK.
<b>MEDLINE®</b> Producer: National Library of Medicine Vendors: B, BC, D, DM, DS, NLM, PC, Q, S	Covers biomedical research and clinical literature. Contains nucleotide and protein sequence database accession numbers.
<b>PASCAL</b> Producer: Centre National de la Recherche Scientifique Vendors: D, Q	Covers the worldwide and especially French scientific and technical literature and conference proceedings. More than 7 000 000 records since 1973. Includes <i>Biotechnologies</i> file.
<b>PATDATA</b> Producer: BRS Vendor: B, BC	Covers more than 700 000 US patents. Contains official abstracts of US patents. 1975 to date.
<b>PTS PROMT™</b> Producer: Predicasts Vendor: B, BC, DS, D	Covers worldwide business literature. Over 1.5 million records. Date of coverage varies with vendor: B, BC, since 1990; DS, since 1978; and D, since 1972.
<b>USPA, USPB</b> Producer: Derwent Publications Vendor: O	Covers US patents since 1971. Entries include all patent claims.
<b>WPI (World Patents Index)</b> Producer: Derwent Publications Vendors: D, O, Q	Covers patent disclosures from 31 issuing authorities. Over four million records with in-depth indexing.

\*Vendor codes: **D**, Dialog Information Services Inc., Palo Alto, CA; **DS**, DATA-STAR, London; **B**, BRS Information Technologies, McLean, VA; **S**, The Scientific & Technical Information Network, Columbus, OH; **BC**, BRS Colleague (Enduser system), McLean, VA; **BCON**, BIOSIS Connection (Enduser system), Philadelphia, PA; **NLM**, National Library of Medicine, Bethesda, MD; **PC**, PaperChase (Enduser system), Boston, MA; **DM**, Deutsches Institut für Medizinisches Dokumentation und Information (DIMDI), Cologne; **O**, Orbit Search Services, McLean, VA; **Q**, Questel, Paris.

NM)<sup>10</sup> is comprehensive, and a guide to sequence analysis has been compiled by von Heijne<sup>11</sup>. The CASSEQ Biopolymer Sequence Service (Chemical Abstracts Service) and other fee-based services offer comprehensive sequence database searches. (CASSEQ, the only commercially available source of patent sequence data, contains protein and nucleotide information.) Patent sequence information will soon be searchable in the GENESEQ database being developed by Derwent Publications Ltd (London, UK) and

IntelliGenetics Inc. (Mountain View, CA).

The MEDLINE® and BIOSIS® bibliographic databases include sequence databank accession numbers which link the literature they index to several databanks containing biomolecular sequence data. These bibliographic databases provide abstracts, standardized index terms and key words which may be used to retrieve citations which include references to sequence database entries. This often precludes the need for complex sequence data-

base searches. Because sequence databases contain no descriptive abstracts and a relatively limited list of keywords, searching bibliographic databases can enhance information retrieved from sequence databases alone<sup>12,13</sup>.

#### Interactive biotechnology information sources

A number of online systems offer communications, file sharing and other computer-based information and data exchanges. Many other computer-based services (e.g. *The*

Microbial Strain Data Network and the *Taxonomic Reference File*) include electronic mail and computer conferencing utilities, which allow access to experts and information from around the world.

BioWorld™ (Io Publishing Inc., San Mateo, CA) is a new online information service providing daily news and analysis, stock indices, company coverage, regulatory and patent reports, and other biotechnology information. The system also furnishes calendar listings, financial data in spreadsheet form, and interactive public or private bulletin boards where users may hold discussions. *BioWorld*™ also includes the *BioScan*™ (The Oryx Press, Phoenix, AZ) directory of biotechnology companies and commercial organizations. Another relatively new service, BioTechNet (Eaton Publishing, Natick, MA) is oriented to research biologists, providing online searching and ordering from company catalogs, listings of research reagents and biochemicals, access to major online database systems and a number of other capabilities. A companion network, BioTechNet Japan (Takara Biochemicals, Ltd., Kyoto, JP), will serve the Japanese biotechnology community.

A growing number of facsimile-based services are available that provide biotechnology and related information. *Bioworld Today* (Io Publishing Inc.) and *Health News Daily* (F-D-C Reports, Inc., Chevy Chase, MD) are transmitted via fax on a daily basis, while *GEN FAX* (Deborah J. Mysiewicz Publishers) is provided via fax once a week.

### Commercial biotechnology information resources

Biotechnology newsletters often contain information of commercial interest, and up-to-date sources of patent, financial, regulatory and other biotechnology-related information (Table 3). Journals and newsletters that contain biotechnology information are useful for tracking current scientific and commercial developments.

A large number of biotechnology company- and organization directories (Table 1), and numerous targeted directories are available. These may cover specific countries (or even metropolitan areas), or specific

**Table 3**

#### *Some newsletters covering commercial aspects of biotechnology*

<b>ABC Details</b>	Association of Biotechnology Companies, Washington, DC
<b>Abstracts in BioCommerce</b>	BioCommerce Data Ltd, Slough, UK
<b>Agricultural Genetics Report</b>	Mary Ann Liebert, Inc., New York, NY
<b>Applied Genetics News</b>	Business Communications Co., Inc., Norwalk, CT
<b>BioEngineering News</b>	Deborah J. Mysiewicz Publishers Inc., Port Angeles, WA
<b>Bioprocessing Technology</b>	Technical Insights, Inc., Englewood, NJ
<b>Biotechnology Bulletin</b>	Scientific and Technical Studies, London, UK
<b>Biotechnology in Japan Newsservice</b>	Japan Pacific Associates, Palo Alto, CA
<b>Biotechnology Insight</b>	Science and Technology Letters, Northwood, Middlesex, UK
<b>Biotechnology News</b>	CTB International Publishing Co., Maplewood, NJ
<b>Biotechnology Notes</b>	Office of Agricultural Biotechnology, US Department of Agriculture, Washington, DC
<b>BioVenture View</b>	Io Publishing, Inc., San Mateo, CA
<b>European Biotechnology Newsletter</b>	Editions Scientifique Elsevier, Paris, France
<b>Genetic Engineering Letter</b>	edited by G. W. Fishbein, Silver Spring, MD
<b>Genetic Engineering News</b>	Mary Ann Liebert, Inc., New York, NY
<b>Genetic Technology News</b>	Technical Insights, Inc., Englewood, NJ
<b>Genewatch</b>	Council for Responsible Genetics, Boston, MA
<b>Human Genome Quarterly</b>	Oak Ridge National Laboratory, Oak Ridge, TN
<b>Scrip, Clinica and Animal Pharm</b>	PJB Publications Ltd, Richmond, UK

industries, such as agricultural or pharmaceutical-oriented biotechnology. Many directories include subject indices providing access to organizations by their products, technologies and research interests. Standard business information resources contain information on many biotechnology companies. Many biotechnology products, processes and organizations

are regulated by various federal agencies (Table 1).

Directories of commercial biotechnology products and services exist, some of which are issued annually as part of subscriptions to some of the major journals, such as the *Guide to Biotechnology Products and Instruments* (the journal *Science*), *Biotech Buyers Guide* (the American Chem-

ical Society), *American Biotechnology Lab Buyer's Guide* (International Scientific Communications Inc.) and the annual *Buyer's Guide* (the magazine *Bio/Technology*). *Linscott's Directory of Immunological and Biological Reagents* (W. D. Linscott, Mill Valley, CA) lists over 30 000 different products, ranging from monoclonal antibodies to recombinant DNA kits.

### Biotechnology patents

Biotechnology patent information can be obtained from several sources, including some databases (see Table 2). A guide to searching online patent databases has been produced by Simmons<sup>14</sup>. For current patent information, many biotechnology newsletters (Table 3) list recently granted biotechnology patents. Some publications are devoted exclusively to reporting recently patented biotechnology inventions, including *Bio-INVENTION* (OMEC, Int'l., Washington, DC). Derwent Publications Ltd (London, UK) publishes a variety of patent bulletins, including *Documentation Abstracts Journal*, *Biotechnology Abstracts* and a variety of patent alerting bulletins, including *Genetic Engineering and Immunoactive Agents*. Customized patent alerting services are also available from Derwent and other organizations.

In the USA, Patent Depository Libraries are located in the majority of states and can be used for patent searching or gathering information. The US Department of Commerce also publishes *General Information Concerning Patents*, providing general patent information, and the *Official Gazette of the United States Patent and Trademark Office* (published weekly) contains official abstracts of US granted patents.

### Conclusion

Biotechnology is moving out of its early, research-oriented phase. Growing numbers of biotechnology information users need access to commercial and technological information. A number of scientific information resources support research and development. Molecular biology data are being collected and organized at ever increasing rates. Success in biotechnology is becoming more and more dependent on the efficient use and handling of diverse types of information.

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## Trends in Biotechnology

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