

Appendix I

The World of Biotechnology Information: Seven Points for Reflecting on Your Information Behavior

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“It is crucial that biotechnology students are able to access the relevant information for their studies and can critically evaluate information and its sources. Information literacy is part of lifelong learning and prepares biotechnology graduates for their careers.” (H. Ward and J. Hockey, 2007, p. 374)

1 Thinking About Your Information Behavior

Information literacy is a crucial key skill for self-directed learning in scholarly and professional everyday life. In addition to efficient retrieval and navigation strategies, it includes – above all – the creativity to organize and shape one’s own information process in a conscious and demand-oriented way. For the searcher, it is no longer questionable to find some information, but rather to filter reliable information from many similar offers. In a time, “where information and data are cheap, proliferating through digital environments and always at the end of a search engine query,” thinking critically about information includes “understanding the process through which truth become authenticated, and the underlying assumptions, values, biases, presuppositions and belief systems which inform that process” (Tredinnick, 2008, p.114).

Like every subject, biotechnology has its own special information media, in addition to particular retrieval strategies, to meet the subject-related information needs. Which of the available databases match your specific needs and are reliable? The so-called “invisible web” or “deep web” contains information sources which are not collected by most search engines such as Google™ – that is, it includes the content of special databases, for example for patents, websites secured by password access or only available in an intranet, and script-based websites, which offer for example dynamic content.

There is a whole range of reasons for reading and informing for research: To provide you with ideas and enhance your creativity; to understand and be able to effectively criticize what other researchers have done in your subject; to broaden your perspective and view your work in context to others (direct personal experience is never enough); to legitimize your arguments; to avoid double efforts in research; to learn more about research methods and their application in practice; and to find new areas for research (Blaxter et al., 2010). Before beginning to search information, first reflect on your topic and specific information needs, gather background information – and then focus your research.

2 Subject Gateways, Tutorials and Literature Guides

Subject gateways on the net, tutorials and literature guides help to inform yourself about searching information. So-called “subject gateways” are good starting points for relevant web sites containing collections of subject-specific links. Two examples are the web resources and Virtual Training Suites of the Intute consortium of British universities at <http://www.intute.ac.uk> and the Engineering Subject Gateway of the TIB/UB, the German National Library of Science and Technology at <http://vifatec.tib.uni-hannover.de/index.php3?L=e>. Special link collections in biotechnology you find in web catalogs such as the Open Directory Projekt (<http://www.dmoz.org/Science/Biology/Biotechnology/>) as well as at web sites like the “U.S. National Center for Biotechnology Information” (<http://www.ncbi.nlm.nih.gov>).

DISCUS (Developing Information Skills & Competence for University Students) is an example of a web-based bilingual (German, English) learning tutorial for information literacy in engineering which can be used independent of time and space. It contains also a module about biotechnology. DISCUS was developed at the University Library of the Hamburg University of Science and Technology and is offered at <http://discus.tu-harburg.de>. Two further examples for online tutorials come from the Dutch

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Delft University of Technology (<http://ocw.tudelft.nl/courses/information-skills/tulib/>) and the Danish Aalborg University (<http://web.aub.aau.dk/swim2/1024/start.html>).

Literature guides provide a comprehensive overview about all forms of primary sources like journal articles, reports, dissertations, patents or preprints and secondary literature (textbooks, monographs, encyclopedias, reviews, abstracting services etc.) of the treated subject. Guides like MacLeod and Corlett's *Information Sources in Engineering* (4th edition, 2005) and Osif's *Using the engineering literature* (2006) contain chapters of specific value for the process and biochemical engineer. A guide for the life sciences comes from Schmidt (2002).

3 Orientation Through Using Encyclopedias and Your Local Library

A range of encyclopedias in chemical and process engineering has been published, including volumes dedicated to biotechnology. These are listed in this book at the end of each chapter. Encyclopedias – such as the Encyclopedia of Industrial Biotechnology – contain a detailed view of evaluated knowledge, in addition to references for further reading. Libraries offer a selected range of such reference works in printed form in their reading rooms. Electronic versions may be available in the local intranet.

Even in the Internet age, a visit to the local university library can ease information retrieval. If they do not possess the item you are interested in, library union catalogs offer a wide range of library materials which can be ordered through interlibrary loan or document delivery. In many countries special libraries function as a National Library for Science and Technology, (e.g., in Germany the TIB/UB in Hannover; <http://www.tib.uni-hannover.de>). Databases available in the local intranet also provide references to further information (e.g. journal articles) not necessarily housed by the library itself. In addition subject librarians can provide information consulting.

4 Playing with Databases and Search Terms

When searching a database it is important to use appropriate key words which allow retrieval of the desired information. Too general key words lead to too many hits from which often only a fraction is useful; when using too specific key words, important information might not be found. It is also recommended to use logical, so-called Boolean operators (AND, OR, NOT) to link search terms and to use wildcard (joker) symbols ('?' or '*' or '\$', which one depends on the search interface). For example, searching with 'biodegr?' retrieves documents containing 'biodegradation or biodegradable or biodegraded or biodegradability or...'. Today's user interfaces allow so-called "facetted search" or "drilldowns" to reduce the number of results after searching. In addition search results are arranged as default setting – in the past often ordered by descending date - according relevance. Here you are faced with the difficulty that it is unknown how relevance is determined by the search engine or database.

A search term worksheet can help to structure your query and to find additional search terms like synonyms. For this, the topic must be divided into components and key words chosen for every component. For searching, terms in each of the worksheet's columns have to be combined with the "OR", the resulting sets with "AND":

Topic: Microbial degradation of aromatic compounds in soil

Component 1	Component 2	Component 3
microbi? degrad?	aromat?	soil?
biodegrad?	polyaromat?	clay?
bioremed?	Benzene	compost?
microbi? decompos?	PAH	sediment?

5 Searching Journal Articles, Patents, and Data

Today, most recent research results are published in scientific journals and subject-specific text books. More and more of these are integrated with databases and other digital media who become more accessible, sociable, and personalized (Hull, Pettifer and Kell, 2008). In addition, patents are an important and often less frequently used source by academia. The difference between primary and secondary sources vanishes. A literature search (see above) provides rapid identification of specific journal articles, reviews and recent books. The original publications can then either be downloaded through the University library homepage as gateway or are available as printed versions in the library (see also: "German Electronic Journals Library" at <http://www.bibliothek.uni-regensburg.de/ezeit/> or the "DOAJ Directory of Open Access Journals" at <http://www.doaj.org/>).

For searching specific papers, the net offers a huge diversity of databases. Free databases like Google Scholar often lead you to fulltexts. In case you are asked for a login or for your credit card number, remember that perhaps the library offers the print version of the article or a further e-version which is only available from another source through the local intranet.

Publishers' portals like ScienceDirect, SpringerLink or the Wiley Online Library offer fulltext searching for their own e-books and e-journals, a feature reference databases like Web of Science or INSPEC don't do. The searchability of information depends on choices made by authors, publishers and database providers (Falciola, 2009). Be prepared for change: Information sources on the net and their user interfaces are updated and enhanced constantly.

A range of databases for information retrieval in chemistry, biotechnology and related fields which are available for free either within the intranet of universities or companies is listed in Table A.1.

6 After Searching: Evaluating and Processing Information

After searching successfully, you have to evaluate your search findings with respect to relevance. How to be sure, that all the potentially important documents are included in your resulting set? How to modify your query to reach this goal? But it is also important to evaluate critically the quality of the documents you have found. In case the document is published in a scholarly peer-reviewed journal, the article has been evaluated by independent experts before acceptance/publication. Who is the author and what is his or her background? Why is the document being provided? How current is it?

The process of information retrieval interweaves more and more – especially in the digital age - with writing and communication processes (Cottrell, 2008; Divan, 2009; Johnson and Scott, 2009; Hofmann, 2010). Networking and collaboration opportunities like weblogs, wikis, and other tools of the "social web" are central themes today and enhance data sharing and new ways to stay current (Cann, Dimitriou, and Hooley, 2011; Oliver, 2009). Subject-specific tools of the "social web" for the bioengineer include resources like <http://openwetware.org/>, a wiki "for researchers and groups who are working in biology and biological engineering", <http://www.proteopedia.org>, a 3D-encyclopedia of proteins and other molecules, or <http://www.cazypedia.org>, an encyclopedia of carbohydrate-active enzymes. To keep yourself up-to-date by getting a free table of contents via e-mail from publishers of journals is replaced through using RSS feeds which can be collected in social feed readers like Netvibes, see for a personal example <http://www.netvibes.com/thapke>. Subscribing to subject-specific mailing lists is substituted through reading subject-specific weblogs or following a researcher via Twitter.

Note-taking strategies today occur by using reference management software like Zotero, Jabref, Mendeley, Endnote or Citavi. Such software allows organising references, quotations as well as full text files. Formatting texts in specific citation styles supports the publishing process.

In addition to impact factors which allow the evaluation and ranking of journals (Journal Citation Reports¹, <http://www.eigenfactor.org/>) there exists further quantitative measures like citation rates and personal impact factors as the h-index to evaluate research through citation analysis (De Bellis, 2009)

¹ Look at http://thomsonreuters.com/products_services/science/science_products/a-z/journal_citation_reports/

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e.g. within Web of Science. Software using Google Scholar as source for evaluation is also available (Harzing, 2011). But “no matter how considerate and extensive a [bibliometric] evaluation is, it will be implemented only to the extent that it is in consonance with the prevailing power structure” at the commissioning higher education institution (Seglen, 2003, p. 151).

7 Information and the World

What is publication – what is an author, a document, a journal, a collection, or a library? In the electronic world of the Internet all of these terms have changed their meaning and use. Thinking about information is particularly of interest in biotechnology (Braman, 2004). At a time when historians of science describe “... biology’s metamorphosis in an information science” (Lenoir, 1999, p.43), it is necessary to reflect about information and its communication and use (Feather and Sturges, 2003). Even new uses of the word biotechnology arise as the the following citation shows: “I also would treat as biotechnology those affective technologies including so-called new media technologies that have permitted us to rethink the body in terms of digitization” (Clough, 2007, p. 312).

In spite of information overload, only a limited part of information is freely available on the Internet. Access to commercial information sources for scholarly research such as reference databases and the fulltext of a specific journal is usually subject to a license fee and controlled by password. However, they are often offered within the intranet of universities or companies. Open access activities try to free access to scholarly publications at least for research and educational purposes. Examples are the journal *PLOS Biology* at <http://www.plosbiology.org> and the journals of BioMed Central at <http://www.biomedcentral.com/>.

Issues in intellectual property and copyright increase in a “cut-and-paste” environment. They are especially part of biotechnology research (Castle, 2009). Why is it important to cite sources of information? What is the right way to cite? Questions of information ethics (plagiarism) as well as information policy (ownership, access, privacy) become important. Does there exist a digital divide? Even think of the preservation and long-term stability of information. What will be happening with electronic records or data in 30 or 50 years’ time?

Literature

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For teaching purposes only!Taken from: Buchholz/Kasche/Bornscheuer, *Biocatalysts & Enzyme Technology*, 2nd edn., Wiley, Weinheim, 2012**Table A.1** Internet databases useful for biocatalysis (selection).

Searching for	Database name and website	Comments
Articles in journals	CEABA-VTB (Chemical Engineering And Biotechnology Abstracts – Verfahrenstechnische Berichte) at http://www.dechema.de/en/ceaba_vtb.html	First choice for process engineering and biotechnology (produced by the Dechema)
	Chemical Abstracts Service at http://www.cas.org	For all areas of chemistry, and related sciences like the materials sciences and the environmental sciences (with user interface SciFinder perhaps in your local intranet)
	COMPENDEX (COMPuterized ENgineering INDEX) at http://www.ei.org/compendex	Most important and comprehensive database for general engineering
	INSPEC (Information Service in Physics, Electrotechnology, Computer and Control) at http://www.theiet.org/publishing/inspec/index.cfm	Of importance because information technology plays a considerable role in all areas of engineering today
	WTI-Frankfurt (Wissenschaftlich Technische Information, formerly Fachinformationszentrum, Specialized Information Center of Technology) at http://www.wti-frankfurt.de/	Databases contain also German resources
	“Science Citation Index” in the “Web of Knowledge” from Thomson Reuters (formerly Institute of Scientific Information ISI) at http://isiwebofknowledge.com	In interdisciplinary citation databases you can search with documents as “search terms” and answer questions such as: Who have cited a specific document? How often is a document cited?
	PubMed at http://www.ncbi.nlm.nih.gov/pubmed	Interdisciplinary for medicine, also of great importance for biotechnology as it allows search of nucleotide or protein sequences, genome data and is linked to enzyme structure databases
	Toxline at http://toxnet.nlm.nih.gov	Toxicology and hazardous substances
	Agricola at http://agricola.nal.usda.gov	For agricultural sciences
Ulidat at http://doku.uba.de	German database for the environmental sciences	

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Patents	DEPATISnet at http://depatiset.net.dpma.de	The German patent information system contains for free the fulltext of every German and American patent in pdf format, also patents from other countries. You have to know the exact patent number. Searching in other database fields – e.g., title, patent inventor, or abstract field – is possible from a distinct year. So you can search for German patents in the title or inventor field from the year 1981
	Esp@cenet, at http://ep.espacenet.com	European patents (European Patent Office)
	US Patent and Trademark Office at http://patft.uspto.gov/	Example for fulltext access to national patents
Chemicals	ChemFinder at http://chemfinder.camsoft.com	Meta-search engine for chemical substances information
	NIST Webbook at http://webbook.nist.gov/chemistry/	Detailed data for many common substances
	InfoTherm by FIZ Chemie at http://www.infotherm.de	Thermophysical experimental data for the daily use of process engineers, tables and charts for about 34,000 mixtures and 9,000 pure substances
	Physical Properties Sources Index (PPSI) at http://www.eqi.ethz.ch	lists recommended databases, handbooks, and websites (data, definition, measurement) for physico-chemical and other material properties
	PubChem at http://www.ncbi.nlm.nih.gov/pubchem	Provides information about chemicals especially relevant for medical sciences
Hazardous substances	GESTIS at http://www.dguv.de/ifa/de/gestis/stoffdb/index.jsp	Free of charge information system of the German institutions for statutory accident insurance and prevention (english version available)
	TOXNET of the at http://toxnet.nlm.nih.gov/	U.S. National Library of Medicine
	International Chemical Safety Cards (ICSCs): International Programme on Chemical Safety at http://www.cdc.gov/niosh/ipcs/icstart.html	Available in a lot of languages

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Enzyme manufacturers (see also Table 5.4, p. 209)	http://www.amfep.org	Homepage of the Association of Manufacturers and Formulators of Enzyme Products. It contains information on enzymes, safety rules for their use, and links to similar organizations, the companies, organizations of importance for the regulation of enzymes (EU, FAO, FDA, WHO etc.)
Enzyme classification and structure	http://www.expasy.ch/	Extensive information on all aspects of proteins/enzymes. Includes enzyme nomenclature database and links to more specialized databases on enzymes
	RSCB Protein Data Bank: http://www.rcsb.org/pdb	A database for 3-D structures of proteins/enzymes and cofactors important for structure and function
Enzyme properties	BRENDA - The Comprehensive Enzyme Information System: http://www.brenda-enzymes.org	A comprehensive database on enzyme properties (k_{cat} , K_m for different substrate; cofactors; inhibitors; stability etc.)
Enzymes, specific	MEROPS – The peptidase database: http://merops.sanger.ac.uk	A database for peptides
	The Lipase Engineering Database: http://www.led.uni-stuttgart.de	A database for lipases, further enzyme specific databases are also available from the Stuttgart group