Chemical Toxicology Searching: A Comparative Study of Online Data-Bases

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Received February 21, 1984

A collaborative project to compare and evaluate information resources and searching techniques for the retrieval of chemical toxicology information has been carried out by 14 organizations. The project involved independent searching of test queries, with subsequent extensive evaluation of results and failure analysis. The results relating particularly to online searching are presented and discussed.

INTRODUCTION

Searching for information on the toxicology of chemical substances is of importance for industrial, governmental, and academic institutions and poses particular problems because of the variety of information sources and searching techniques available.[1-4] A comparative evaluation project was therefore organized between 14 European organizations, to thoroughly assess the strengths and weaknesses of information resources in this subject area with a view to gaining insights into optimal search techniques in this subject area. The participating organizations are listed in Table I. We were fortunate to be able to draw on the experience of participants in the only previous collaborative evaluation of this topic.[5] The full results of this project are set out elsewhere:[6] here we present those apsects of particular relevance to online searching.

It was decided to use the "test query" method of evaluation, with queries designed to cover the whole area of interest and to highlight particular aspects of retrieval and points of potential difficulty. The queries were also chosen, so far as possible, to give an appropriate number of references for analysis, since it was thought better to analyze a smaller set of results qualitatively and in detail rather than a larger set quantitatively in a more cursory manner.

Eight test queries were chosen and are listed in Table II. Each was searched by the participants using what they regarded as the most appropriate sources (online, printed, or in-house files) and searching techniques. The results were consolidated and extensively analyzed by a different "umpire" for each query, who made further searches where necessary and carried out a failure analysis. This procedure, though time consuming, meant that the overall results of the evaluation were not affected by differing levels of expertise and experience among the searchers nor by different relevance judgements. Conclusions drawn about any source or searching technique did not depend upon the viewpoint of any one participant, and highly diverse approaches to searching were brought together in summary. Recall figures were studied in detail, because of the importance of comprehensive retrieval in this subject area,[2] and are quoted for each source as total number found and number unique to that source. Precision was less easily analyzed, because of the very different searching techniques used, and is therefore commented on qualitatively. This project methodology is more fully described elsewhere.[6] We believe that it was successful in enabling the project to meet its twin objectives of improving the participants' expertise in searching queries of this sort and of providing generally applicable guidelines to such searching.

Costs of searching have not been explicitly considered, since these are so affected by local factors and change so rapidly over time that any attempt to produce meaningful extrapolations to a general case would be a major undertaking. Where a particular search technique proved very time consuming, this has been noted.

Table I. Participants

Beecham Medicinals Research Centre (UK)
British Industrial Biological Research Association (BIBRA) (UK)
Ciba-Geigy (Switzerland)
Department of the Environment (UK)
FBC Ltd. (UK)
Gist-Brocades (Netherlands)
Glaxo Group Research (UK)
Huntingdon Research Centre (UK)
ICI Central Toxicology Laboratory (UK)
Pfizer Central Research (UK)
Phillips-Duphar (Netherlands)
Poisons Reference Centre (UK)
Royal Postgraduate Medical School (UK)
Wellcome Research Laboratories (UK)

Table II. Test Queries

(1) all toxicity of sodium bismuthate
(2) carcinogenicity and mutagenicity of quinoline compounds, excluding quinoline *N*-oxides
(3) long-term experimental carcinogenicity studies in laboratory animals, on vinyl chloride monomer, carried out since 1976
(4) tetratogenic, or other reproductive, effects in humans occupationally exposed to methylbenzenes
(5) piscine toxicity of propoxur
(6) hindlimb abnormalities in mammals, caused by tetratogenic chemicals, excluding thalidomide
(7) mammalian toxicity of orally administered cinnamic acids, salts, or alkyl esters
(8) all toxicity of nitrofen

RESULTS

(Query 1) All Toxicity of Sodium Bismuthate. This query was designed to investigate problems in searching for the toxicity of a substance for whch medical use and, hence most toxicity studies, occurred some decades ago. Seven participants searched this query.

A total of 21 relevant references were found, and the retrieval from various sources is summarized:

	total	unique
Chemical Abstracts (printed)	14	4
Excerpta Medica (printed)	2	2
TOXLINE	1	0
RINGDOC	2	1
books	8	2
cited in other papers	3	3

A number of other online data-bases were searched without success. Of the 21 references, 19 were published prior to 1950. Thus, virtually all this material predates the online retrieval systems, and the need to rely on printed sources is reflected

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in the results. One reference was found uniquely in *RINGDOC*. This reference was potentially difficult to retrieve, since it described the effects of a very large number of chemicals: it was in fact found by searching the *RINGDOC CLEARTEXT*, a good indication of the need to use the specialized searching facilities of each source for complete retrieval. This paper was also present in the online version of *Chemical Abstracts* but without specific substance indexing: it was not present in *MEDLINE*.

This test query is a good example of the need for access to a collection of specialized, and in some cases "out-dated", printed material for some chemical toxicology queries. It does however also point to the value of the online systems, even for searches where they would at first sight appear unsuitable, and to the need for making use of all available searching techniques.

(Query 2) Carcinogenicity and Mutagenicity of Quinoline Compounds, Excluding Quinoline *N*-Oxides. This query was designed to investigate difficulties of chemical substructure searching, involving NOT logic, and of the specification of carcinogenicity and mutagenicity.

A large number of references (several hundred) apparently relevant to the query as posed were identified by the participants. Only 56 of these references were considered be "salient", giving information on a total of 78 different substances. No detailed quantitative analysis of the results was made; some conclusions emerged clearly, however.

Chemical Abstracts, used in both printed and online form, was used by all participants and gave about 70% of the relevant references. *RINGDOC* produced 45% of the total, and none of the remainder of a variety of data-bases used gave any large proportion of the references. The *NIOSH Registry of Toxic Effects* (*RTECS*) online data-bank gave information on only 10 of the 78 compounds of interest, and the PHS 149 data-bank of compounds tested for carcinogenic activity gave information on a similar number.

Two particular aspects of the information resources used had a great effect on the nature of searches for this query: the organization of records and substructure-searching facilities.

Where sources are organized with the bibliographic reference as the basic record, as in all the text-based bibliographic online systems, many repetitive "relevant" references may be produced if a single compound is frequently used as a standard in testing: this was the case here for 8-hydroxyquinoline. Also, NOT logic, e.g., here to negate *N*-oxides, is dangerous, since relevant and irrelevant compounds may be mentioned in the same reference. Data-banks organized by chemical structure (e.g., those on the NIH-EPA Chemical Information System[7]) do not suffer from these problems.

Direct substructure-searching facilities (as in the NIH-EPA files and CAS ONLINE/DARC) are also highly advantageous for searches of this sort. Text searching in bibliographic files led to much irrelevance. Chemical dictionary files[8] are a valuable aid, but extensive use tends to be time consuming. It was the experience of the participants in this query that use of a data-bank with substructure-searching capability is a particularly convenient way of carrying out searches of this sort, particularly if references and data are directly available online (as is the case at present with RTECS but not with PHS-149).

The specification of carcinogenicity or mutagenicity posed relatively few problems, compared with those of substructure search. The concepts could be searched for directly, by using toxic effect codes, in RTECS and required a relatively small profile of terms in the bibliographic data-bases.

It appears that the use of computerized data-banks with substructure-search capabilities is the most convenient way of dealing with queries of this sort. Since the coverage of these data-banks, on the evidence of this query, may not be sufficient for them to be used as a single source, it will generally be necessary to back them up with the bibliographic data-bases. *Chemical Abstracts* seems to be the best of these, and the printed indexes, or substructure-searching systems, are the best way of dealing with the problem; alternatively, chemical dictionary files should be used, to locate Registry Number identifiers, rather than text searching in the bibliographic files, which yields poor results. The biomedical files provide useful backup, particularly in finding additional references to specific substances.

(Query 3) Long-Term Experimental Carcinogenicity Studies in Laboratory Animals with Vinyl Chloride Monomer, Carried Out Since 1976. This query was designed to highlight the problems encountered in searching for recent examples of a tightly defined experimental toxicology study (carcinogenicity: long-term, laboratory animal) on a well-defined widely used chemical substance with many synonyms. Eleven organizations participated.

A total of 94 relevant references were identified, spread over a large number of data-bases. Fourteen online sources provided some relevant material, but no individual source gave much over 50% of the references. The total and unique references for each online source are

	total	unique
in-house files/printed sources	63	18
TOXLINE	50	8
MEDLINE	29	2
CANCERLINE	25	4
Chemical Abstracts	18	0
BIOSIS	17	0
Excerpta Medica	13	2
Scisearch	8	1
RTECS	6	0
NTIS	4	4

Databases giving three or fewer nonunique references were *Pollution Abstracts*, *Food Science and Technology Abstracts*, *Smithsonian Science Information Exchange*, *RINGDOC*, and *Enviroline*.

The major chemical and biomedical files all give reasonable retrieval. The good performance of *TOXLINE* is perhaps to be expected for an experimental toxicology search,[2] whereas *BIOSIS* did not perform as well as might have been expected. Two other data-bases gave unique references, a very recent paper found in *Scisearch* (emphasizing its value for current material) and four governmental reports from NTIS. It is plain that for this query a variety of sources, printed as well as computerized, needed to be used to approach comprehensiveness. Thus, considering only the online data-bases, *TOXLINE* gave just over 50% of the references, *TOXLINE* plus *MEDLINE* gave 60%, and a combination of the six main chemical/biomedical resources gave 75%.

Search strategies were difficult to construct, with each of the four components of the search causing problems: (*i*) *Long-Term*. The concept is not adequately indexed in any data-base; when it was included in the search strategy, the retrieval fell dramatically. (*ii*) *Carcinogenicity*. A variety of specific terms were used in the indexing, particularly in the biomedical data-bases. (*iii*) *Vinyl Chloride*. The variety of synonyms used made retrieval difficult, except in data-bases using systematic substance identification (e.g., Chemical Abstracts Service Registry Numbers). (*iv*) *Laboratory Animal*. Specification of this concept, to exclude studies on human exposure and in vitro testing, was made difficult since most data-bases index by species names, and thus, a profile of individual species (rat, mouse, etc.) had to be used.

Because of these problems, the only search strategies to find any high proportion of the references were those restricted to specification of "vinyl chloride" and "carcinogenicity" with

Table III

	covered	retrieved	irretrievable: no substance indexing	irretrievable: no occupational exposure indexing
MEDLINE	8	4	4	0
TOXLINE	12	9	3	0
Chemical Abstracts	9	7	1	1
BIOSIS	7	3	3	1
Excerpta Medica	4	3	1	0

subsequent scanning through the several hundred references produced to remove irrelevance. Any more detailed approach missed many references, because of the problems of specification of "laboratory animal" and/or "long term".

This query shows the necessity for use of profiles of terms not only for chemical substances but also for apparently straightforward concepts such as "carcinogenicity" and "laboratory animal" and indicates the failure of data-base indexing in one specific point of importance in toxicology searching, i.e., study length.

(Query 4) Teratogenicity, or Any Other Effect on Reproductive System, in Humans Occupationally Exposed to Methyl Benzenes. This query was designed to examine problems in searching for a wide variety of reproductive effects in humans, associated with a closely defined group of compounds (12 in all). Six organizations participated.

A total of 16 relevant references were found, and the retrieval from each source was as follows (online except for the first):

	total	unique
printed sources/in-house files	10	4
MEDLINE	4	0
TOXLINE	9	0
Chemical Abstracts	7	0
BIOSIS	3	0
Excerpta Medica	3	0

Seven other data-bases were searched without success. If the use of printed sources and in-house files are discounted, three of the *Chemical Abstracts* references and one from *TOXLINE* are unique. *TOXLINE* and *Chemical Abstracts* are plainly the preferred data-base combination: if *TOXLINE* were not used, then a combination of *Chemical Abstracts* and a biomedical data-base would be necessary for adequate retrieval.

Of the 14 references included in any online file, the coverage and number retrievable and irretrievable online by any reasonably precise search strategy is shown in Table III. Low retrieval resulted from a lack of detailed substance indexing, particularly in the biomedical data-bases. In both *Chemical Abstracts* and *BIOSIS* there was one reference with no indication of occupational exposure. The poor coverage of *Excerpta Medica* is due to its smaller time period online, since most references were not particularly recent.

The search strategies used were necessarily rather complex, and involved three concepts: (*i*) *Methyl Benzenes*. Since only 12 compounds were included within this definition, they were specified directly, without any need for generic structure searching: use of Chemical Abstracts Service Registry Numbers was essential. (*ii*) *Occupational Exposure*. This concept caused problems since, in each data-base, some relevant references had no indexing for this concept. In general, the "broad" searching facilities, *BIOSIS* concept codes and *Chemical Abstracts* section headings, were more useful than free-text searching. (*iii*) *Reproductive Effects*. This gave considerable problems, and required a profile of search terms. Neither the controlled indexing of the medical data-base nor the BIOSIS concept codes dealt conveniently with the whole spectrum of biological effects: searchers who relied on "teratology" codes and headings missed a number of references. The essentially free-text *TOXLINE* file proved particularly difficult: specifying the Environmental Teratogenicity Information Center (ETIC) subfile appeared to be the best way to get reasonable accuracy of retrieval. In general, this search exemplifies the need to use a variety of information resources and to use profiles of search terms: when this was not done, retrieval was poor.

Table IV

	covered	retrieved	irretrievable[a]: no substance indexing	irretrievable[a]: no toxicity indexing	irretrievable[a]: no fish indexing
Chemical Abstracts	17	13	2	2	1
TOXLINE	16	14	2	1	0
BIOSIS	5	3	2	0	0
Excerpta Medica	3	3	0	0	0
C.A.B.	4	2	2	2	0

[a] Note that each reference could fall on more than one count.

(Query 5) Piscine Toxicity of Propoxur (Piscine Meaning Any Species of Fish but Not Other Aquatic Organisms). This query was designed to illustrate problems in searching for pesticide toxicity in nonmammalian species.

Six participants searched this query, and a total of 18 relevant references were found. Online bibliographic data-bases were the main resource, because the required material was mostly recent and because of the combination of concepts required. The retrieval is summarized as follows:

	total	unique
Chemical Abstracts	13	1
TOXLINE	14	0
BIOSIS	3	0
Excerpta Medica	3	0
C.A.B. Abstracts	2	1

One nonunique reference was found also in *Pollution Abstracts*, *ASFA*, and *IRL Life Sciences*; 10 other data-bases were searched without success.

Chemical Abstracts and *TOXLINE* are plainly the best sources, largely because of their coverage (see below). Only one reference would not have been retrieved by a combination of these data-bases; a paper in a journal covered only by Commonwealth Agricultural Bureau (C.A.B.). Two references were found in the CA sections of *TOXLINE* but not in *Chemical Abstracts* itself (because of additional access points in the *TOXLINE* abstract), and conversely, two references were found in *Chemical Abstracts* and not in *TOXLINE*. It should not therefore be assumed that these two data-bases are equivalent for this sort of search.

One participant searched printed *Chemical Abstracts* but found only 8 of the 16 references present, largely due to lack of information in the indexing phrases qualifying the subject heading, which did not indicate the piscine toxicity aspects of the reference. Clearly, in this case the online implementation of a data-base allows superior retrieval to the printed form.

A failure analysis for the main data-bases is shown in Table IV. Lack of indexing for specific substance, toxicity, and fish all occur for some references. The strong superiority in coverage of *Chemical Abstracts* and *TOXLINE* is evident. Two of the references were present in *Agricola* and one such in *Scisearch*, *Environline*, and *Dissertation Abstracts*, but were not retrievable by anything other than the broadest search strategy because of lack of indexing of substance and/or toxicity.

The three components of the search were as follows. (*i*) *Propoxur*. Lack of detailed substance indexing caused problems, in files other than *Chemical Abstracts* and *TOX-*

LINE. In all data-bases, a profile of synonyms, plus CA Registry Numbers where present, was necessary. (*ii*) *Piscine*. Relevant references were missed in some cases, because only species names for fish were used in indexing. A profile of generic terms and species names such as "trout" and "crayfish" was essential for good retrieval. If this concept was omitted, searching for all aquatic toxicity of propoxur gave many irrelevant references. (*iii*) *Toxicity*. A number of references in each data-base had no "toxicity" indexing terms. Some participants did not search specifically for this concept, since the combination of the propoxur and fish concepts was reasonably precise. Synonyms such as "malformation" and "lethality" were necessary.

(Query 6) Hindlimb Abnormalities in Mammals Caused by Teratogenic Chemicals, Excluding Thalidomide. This test query was designed to highlight the factors involved in searching for a particular toxic effect, without specification of any chemical substance.

The searches, using biomedical data-bases as noted below, produced a large number of relevant references, from 100–150 in the recent literature alone. They were not analyzed quantitatively, since the conclusions were evident without requiring this.

No suitable data-bank, structured by chemical compound, exists for this sort of query, and the participants relied on the biomedical data-bases: (*i*) *MEDLINE*, using the controlled terms, HINDLIMB, LEG BONES, etc. and TERATOGENS, ABNORMALITIES, DRUG INDUCED, etc.; (*ii*) *TOXLINE*, using a profile of free-text terms and the *ETIC* subfile; (*iii*) *RINGDOC*, using a combination of free-text terms and biocoding.

All three data-bases enabled large numbers of relevant references to be retrieved, but two searching problems were noticed. The use of NOT logic to remove unwanted thalidomide references resulted in relevant papers, mentioning other teratogenic agents, being missed. Also, in each data-base, a substantial proportion of the records were indexed nonspecifically: "limb", "toe", etc., so that the concept of "hindlimb" could not be specified. This was, in some cases, a problem stemming from the primary literature.

The test query indicated that reasonable searches may be performed for specified teratogenic effects of unspecified chemical substances, by using the biomedical online services, with the searching problems noted.

(Query 7) Mammalian Toxicity of Orally Administered Cinnamic Acids, Salts, or Alkyl Esters. This search was designed to examine the problems involved in searching for all toxicity, by a defined route of administration, for a class of compounds (i.e., a substructure search). Six organizations participated in this test query, and 32 relevant references were identified. There was a preponderance of older material, and of these 32, only 11 came within the time span of any of the online systems, the remainder being found in in-house files and printed sources. An analysis of the online retrieval of the 11 is shown in Table V. Lack of substance indexing is seen to be a problem with several sources here, particularly since several references were reviews in *Food and Cosmetic Toxicology*, for which detailed substance indexing was not applied (this also occurred with other references beside these 11). Toxicity indexing was lacking in a number of cases also.

The substructure search aspect proved the most difficult part of this query, and as in query 2, three approaches (printed chemical name index, bibliographic textual data-base, and data-bank) were used. Use of the NIH-EPA version of *RTECS* produced nine references by substructure searching and direct specification of oral toxicity. The same references were found by other participants from a combination of the printed indexes and the implementation on the British Library

Table V

	covered	retrieved	irretrievable: no substance indexing	irretrievable: no toxicity indexing
RTECS	3	3	0	0
Chemical Abstracts	11	8	2	1
Excerpta Medica	9	7	1	1
RINGDOC	4	4	0	0
BIOSIS	6	4	2	0
TOXLINE	10	10	0	0
Food Science and Technology Abstracts	5	1	3	1

BLAISE system, involving more time-consuming and rather convoluted searching. *Chemical Abstracts* was not used online by any of the participants, those who used this source preferring to search the printed indexes, because of the difficulty of substance specification in a computerized text search. The biomedical data-bases, particularly *Excerpta Medica* and *RINGDOC*, did give some useful references, although at the cost of retrieving much irrelevant material. Profiles of terms for "toxicity" and "oral" were required. This search caused particular problems because of the spread of material across a number of sources and because of indexing failures, as well as the problems of substructure searching. It is clear that a variety of sources, including printed material, is necessary to obtain a successful result in searches of this sort and structure-oriented data-banks are a particularly useful way of searching. Because of their lack of comprehensiveness however, they are at present only adequate as a starting point, and the biomedical files must be used to find supplementary references.

(Query 8) All Toxicity of Nitrofen. This query was designed to highlight the problems of searching for all toxicity (including acute, subacute, and chronic toxicity, carcinogenicity, mutagenicity, and teratogenicity and other reproductive effects) of a single compound (in this case a pesticide).

Eleven participants searched this query, and a total of 65 relevant references were identified. A wide variety of computerized, printed, and in-house sources were used. The retrieval from the main sources is summarized:

	total	unique
TOXLINE	38	7
Chemical Abstracts (online)	20	1
BIOSIS	6	0
Excerpta Medica	6	0
RTECS (BLAISE)	6	0
in-house files/printed material	64	18

Again a large proportion of the references were not found online largely because of coverage limitations, primarily of older material. On the other hand, it is clear that the online files play a major part in obtaining good retrieval. If in-house files and printed material are ignored, the unique references produced are as follows: *TOXLINE*, 13; *RTECS*, 1; *Chemical Abstracts*, 1. The preeminence of *TOXLINE* is largely accounted for by its excellent coverage of pesticide material, particularly in the PESTAB subfile. In addition, *TOXLINE*, because of its varied composition, is often useful for "general toxicity" queries, although the amount of duplication and nontoxicity material present may make its use very difficult, particularly for widely used substances. The retrieval from *RTECS*, and from all the biomedical files, is far from comprehensive, and only *Chemical Abstracts* produces any comparable number of references to TOXLINE. Substance specification required use of both Chemical Abstracts Registry Number and synonyms.

The concept of "all toxicity" gave many more problems, and some participants lost many references by failing to use a

sufficiently broad profile of synonyms. For good retrieval in the online files, it was necessary to use keywords reflecting all aspects of toxicology and to include specific searching features such as *Chemical Abstracts* sections. In hindsight, the simplest keyword strategy to retrieve all the references included in the online data-base would be (? indicates truncation): CARCINO? OR LUNG OR PULMONARY OR PHARMACOLOGICAL OR MUTA? OR RAT OR DERM? OR METABOL? OR INTOXICAT? OR POISON? OR WORKER? OR TOXIC? OR OPHTHALMIC OR EYE.

This does however lead to many potential irrelevancies because of very general terms such as PHARMACOLOGICAL, RAT, and METABOL? and highlights the problems of identifying "all toxicity" by free-text searching. This query illustrates the need to use both online and printed sources in searching for all toxicity of a specified substance and emphasises the value of *TOXLINE* for pesticide searches.

DISCUSSION

The results of this project have illustrated a number of important aspects of searching for chemical toxicology information. To some extent they confirm earlier suggestions,[2] but new insights have certainly emerged.

First, it is clear that the use of a variety of sources, both printed and computerized, is essential to obtain good retrieval in this subject area. Online data-bases and data-banks are an indispensable component of such searches, even where much of the material is old. In those cases where direct comparison was possible, online searching proved generally more effective than using the corresponding printed index, because of more detailed indexing and easier concept combination.

Bibliographic data-banks are plainly very important resources for searches for this sort. *Chemical Abstracts* appeared as the single most valuable source for these queries. *TOXLINE* (allowing for its problems of duplication and inclusion of nontoxicity material) was also important, particularly for those queries involving pesticides or "general toxicity". These two data-bases are shown to be not equivalent, and their combination proved powerful in a number of these queries. The biomedical data-bases (especially *RINGDOC* and *Excerpta Medica*) also gave useful material and generally of most value for "backup" searching. The combination of *Chemical Abstracts* with one of these was often valuable. The need for use of diverse resources was shown by the retrieval of unique references from apparently peripheral data-bases e.g., *Sci-search* (for very recent material) and *C.A.B.* (specialized coverage). In general, a multiple approach was essential to overcome limitations of coverage and searching facilities of individual data-bases.

Data-banks, with their record organization by chemical structure, specialized searching facilities, and direct link of structure to toxicity data were particularly valuable for some queries. Limitations of coverage at present dictate their use only as a starting-point, if a fully comprehensive search is required.

A variety of searching technique within the sources chosen, making use of the specialized searching facilities of each data-base (e.g., *TOXLINE* subfiles and *BIOSIS* concept codes), was also seen to be essential. Profiles of search terms were required for many concepts (e.g., "all toxicity", "reproductive effects", "laboratory animals", and "occupational exposure"). Chemical substructure searching was a particular problem, and specialized searching facilities were used to good effect in some queries.

The evaluation of the queries also indicated a number of failings in coverage and indexing in the sources used, stemming in some cases from the primary literature. Particular problems are highly specific indexing of animal species, toxic effect, etc. and nonindexing of toxicity when it forms only a minor part of a publication. These problems, and possible solutions, are discussed more fully elsewhere.[6]

In general, the project methodology worked well, the extensive failure analysis allowing compensation of varying levels for experience of participants and the inclusion of diverse information resources and searching techniques. The success of both objectives of the evaluation, educative and objective assessments, lead us to believe that this form of collaborative evaluation may be of more general application in other subject areas.

CONCLUSIONS

The following major conclusions regarding online searching for chemical toxicology information may be drawn: (i) Online searching is an essential component of virtually all chemical toxicology searches but must be complemented by printed sources. (ii) A multifile approach is virtually always required. (iii) The specialized searching facilities of each data-base should be utilized. (iv) Profiles of search terms are necessary for many concepts. (v) Data-banks have significant advantages over bibliographic data-bases for many such searches.

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