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1. The State-of-the-Art in the Field of Biotechnology Information

The availability of high quality, up-to-date and comprehensive information is an important requirement in biotechnology and its applications in ever wider fields of medicine, ecology, agriculture and food industry. The last ten years have seen a considerable and at the same time necessary increase in the amount of available information on biotechnology.

We have analysed **the information market** regarding factual and bibliographic databases relevant to basic and applied fields of biotechnology [1][2]; and **the users' needs** in selected areas of biotechnology, especially in the field of genetic engineering.

Starting out from the results of these investigations we can state: The consequences of the rapid development in biotechnology with the increasing growth of data on the one hand, and the possibilities of information technology on the other hand, are **very large databases** containing different kinds of information (bibliographic, factual, referral and full-text information) and **highly sophisticated software** for processing and using of these databases.

As a result a new discipline has been developed: BIOINFORMATICS.

The development of bioinformatics is connected with:

- the organization of a comprehensive **information service** including
 - various possibilities for the availability of databases (magnetic tape, floppy disk, CD-ROM);
 - communication networks (online access, electronic mail, computer conferencing);
 - special information processing services;
- the enhancement of **international co-operation** with the purpose of increase and coordination of the information exchange, and establishment of only a few, but powerful information centres for collection, processing, and exchange of data;
- high governmental and industrial **investment** to provide the pre-conditions necessary for the establishment of databases at which there are great differences between funding of bioinformatics in the USA and Europe on the one hand, and between Western Europe and Eastern Europe on the other hand [3];
- very different **information needs** of users in research and industry influenced by the multi-disciplinary character of biotechnology, and the different kinds of necessary information (bibliographic information; factual information, e. g. sequences, structures, spectra, as well as financial and business information; referral information, etc.).

The new discipline "**Bioinformatics**" is an essential part of biotechnology that underpins not only research and development but also commercial, legal, and regulatory activities.

The enlargement of the information market in biotechnology is also connected with specific problems. Some of them are of general character, and another are connected with the former GDR structures:

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1. Insufficient Appreciation of "Information" as a "Knowledge" Resource

Reasons:

- an underdeveloped information awareness;
- we have not learned to use "information" as a resource comprehensive and to transform the provided information into knowledge.

2. The Necessary Pre-conditions for the Setting-up and Use of Databases are Insufficiently Provided

Reasons:

- the willingness to national and international co-operation does not meet the requirements;
- the effort in setting-up databases is underrated and thus there is a lack of provision of the necessary manpower, financial resources and equipment;
- the information management is underdeveloped.

3. The Interfaces Between Research and Information are Insufficiently Developed

Reasons on the side of information:

- the "classical" understanding of documentation continues to prevail;
- the necessary pre-conditions for a comprehensive information service do not exist.

Reasons on the side of research:

- a lack of possibilities as a consequence of inadequate pre-conditions or insufficient data quality, but also unwillingness to feed research findings into databases and thus make them more widely available;
- occasionally a dangerous **ignorance** is exhibited with regard to information.

4. The Guarantee of the Quality of the Database

concerning

- **the actuality of the database** determined by the time it takes to make new information available on a database, and by the possibility of rapid access to the database;
- **the reliability and accuracy of data** connected with the necessity
 - to integrate evaluation algorithms,
 - to expand the syntactic and semantic representation possibilities,
 - to formulate requirement characteristics;
- **the complexity of data and databases** connected with the necessity
 - to crosslink different (kinds of) information which are part of different (kinds of) databases,
 - to combine different forms of information representation,
 - to extend the numeric data by means of supplementary, descriptive information,
 - to use standardized or easily translatable formats which must be interconnected.

5. The Necessity of a Referral Database System

with information of the kind "Who, What, Where" building one of the bases of information brokerage.

2. The Establishment of the "Biotechnology Information Service"

2.1. Starting Point

The GDR's situation in the field of biotechnology information was characterized by the fact that:

- the information possibilities were (are) inadequate;
- the existing information possibilities were (are) insufficiently known and the routes were (are) troublesome;

- precisely in regard of information from or about the former GDR there is a lack of knowledge.

Starting out from this situation it was determined in March 1988 to establish a "Biotechnology Information Service" [4].

2.2. Objective

The "Biotechnology Information Service" improves the information provision in the field of biotechnology and is a powerful information tool. It serves the scientist as an information guide which stewards him through the information landscape to the desired information. This service helps especially the scientists in the five new states of Germany as well as in Eastern Europe.

2.3. Tasks

The activities of the "Biotechnology Information Service" include

Information brokerage

- **online access** to the international hosts Data-Star, STN International, FIZ Technik, ECHO, ICECC, GENIOS, etc.
- **searches in its own databases:** "Information Sources in Biotechnology", "Who-What-Where in Biosciences and Biotechnology", "Conferences in Biotechnology";
- **offline use of other databases** which are obtained on CD-ROM or diskettes, and implemented by the "Biotechnology Information Service" such as Science Citation Index, EMBL Nucleotide Sequence Data Library, SWISS-PROT Protein Sequence Database, and others.

Setting-up of own databases

- Information Sources in Biosciences and Biotechnology

This database contains information on information sources (databases, special information materials, periodicals, books, software, etc.) in the fields of biotechnology.

- Who-What-Where in Biosciences and Biotechnology

This database contains information on institutions and companies working in the various fields of biotechnology including information on research projects, products, technologies, services, culture collections, etc.

- for the five new states (former GDR);
- for East European countries.

Conferences in Biosciences and Biotechnology;

- **Publications** on the basis of the own databases, and as a result of information analysis and synthesis (state-of-the-art reports, reviews, bibliographies);
- **Consulting** concerning bioinformatics projects, research support, as well as making research and business contacts.

2.4. Contents

Because of the multidisciplinary character of biotechnology and the variety of questions directed to the "Biotechnology Information Service", the **basic fields of biotechnology** (molecular biology, genetics, cell biology, biochemistry, biophysics, microbiology, and others) as well as the **fields of applied biotechnology** (medicine and pharmacy, chemistry and chemical engineering, agriculture and nutrition, ecology, etc.) are included.

2.5. Pre-conditions

The pre-conditions necessary for the establishment of the "Biotechnology Information Service" include

a) Data Input. The acquisition of the necessary information is one of the main difficulties. At present we employ the distribution of questionnaires, the extraction of information from literature and from other referral databases;

b) Controlled Vocabulary. For indexing and retrieval of information are used the "Thesaurus Biotechnologie" (in German) and the BIOREP thesaurus [5][6];

c) Investment. The establishment of databases requires considerable investment. The role of information will be determined by the fact how a society answers the economic questions concerning the production of information, the distribution of information, and especially concerning the **development of an information infrastructure**;

d) Price "Policy". Everybody has to accept that an information has its price. This insight depends on the information awareness and the importance of this information;

e) A Qualified Staff including Information Management. The interaction between biotechnology and information science demands a "hybrid" knowledge. It is necessary to take into account that at an international level considerable attention is paid to information management.

2.6. Availability

a) In printed form for ready availability of information as reference books:

- Directory of factual databases in the field of biotechnology [1];
- Directory of bibliographic databases in the field of biotechnology [2];
- Directory of information sources in the field of biotechnology published in the GDR [7];
- Directory of periodicals in the field of biotechnology [8];
- Who-What-Where in biosciences, biotechnology and genetic engineering in the former GDR [9];
- Conferences, workshops, fairs in the field of biotechnology [10].

b) In the form of databases containing more information than the printed versions.

● **The database "Information Sources"** provides answers to the following questions:

Which information sources are available in the fields of biotechnology?

Does a particular source of information exist and where is it available?

What software is available for processing biotechnological data (e.g. sequences, structures)?

● **The database "Who-What-Where"** provides answers to the following questions:

Which research institutions and industrial firms in the former GDR and in Eastern Europe are working on what research projects and supply which products or provide which services relevant to biotechnology?

The database "Who-What-Where" contains

- addresses
- research information
- information on R&D projects
- product information
- technology information
- service information
- information on culture collections
- information on basic and further training opportunities
- co-operative relationships.

- The database "Conferences" provides answers to the questions concerning time and locations of conferences, workshops, and fairs.

2.7. Further Development

The aims of the **further development** of the "Biotechnology Information Service" are to participate in the **BIOREP project**, as well as in other directory projects of relevance to facilitating coordination of national biotechnology programmes and transnational collaboration; and to provide a basis for the **coordination** of research and the application of research results in the field of biotechnology. In this way, the "Biotechnology Information Service" could help to support the planning of research, and to **prevent parallel work**.

Another aim will be to connect the both German biotechnology information services: **BIKE** (Biotechnologie-Informations-Knoten für Europa), and **AuBit** (Auskunftsdienst Biotechnologie).

At a later point of time we will investigate the necessity and the possibility of application of artificial intelligence methods. The aim could be to develop an **expert system** which would assist both information scientists and end-users in a referral situation.

3. Conclusions for the Future of Biotechnology Information

1. Formation of a new information awareness and behaviour in the conviction that information comprises an indispensable component of all fields of science and technology.

2. Implementation of a European biotechnology information infrastructure in connection with the creation of the necessary pre-conditions

- for the **use of the large international databases** for which there are no national equivalents;
- for the **setting-up of specific databases** which contain information on research findings and are available either as independent databases or as data input for international databases;
- for the **inclusion and improvement of the East European** information market.

3. Development of a highly sophisticated software

With the large databases we have a huge information potential at our disposal, but we are not able to utilize it to a high degree. A **highly sophisticated software** is required in order to make the knowledge contained **implicitly** in these large databases **explicitly** available. Especially **artificial** intelligence methods should be introduced in order to improve the processing of different kinds of information. In the future, various forms of representation patterns will have to be combined in order to be able to adequately and completely represent objects' properties, relations and interrelations, and to transfer information into knowledge.

4. Importance of factual information

Factual databases derive their importance from the following:

They provide a **research instrument**, which

- as a consequence of its indispensability for certain types of problem solving, has led to the formation of a new attitude toward information on the part of scientists;
- arises at the interface between subject area and information science whereby the scientist increasingly assumes the role of producer and user of information;
- bears witness to the increasing influence of information technologies on the research process [11].

The factual databases have to provide information required for Computer Aided Design, e.g. protein design, and as a part of the **knowledge bases** of expert systems [12].

5. Participation in the international information exchange

The increasing amount of information and the considerable expenditure involved cause the gathering, processing and distribution of information to be possible only with **international scientific co-operation by means of modern information technology. Maintenance of international databases is particularly important to provide timely access** to information from research.

Proceeding from the fact that significant databases in the field of biotechnology like nucleotide sequence, protein sequence, hybridoma and culture collections databases, etc. can only be created through **international co-operation**, it is **imperative** that all countries participate in the international information exchange.

At present time, the basis for an international co-operation is so good than never before. **We should use this chance!**

Acknowledgement

The project "Biotechnology Information Service" is supported by the Federal Minister for Research and Technology (BMFT), Germany.

Streszczenie

W artykule została przedstawiona sytuacja w zakresie informacji biotechnologicznej na terenie byłej NRD (po unifikacji państwa niemieckiego) w aspekcie potrzeb użytkownika oraz rynku informacyjnego. W tym kontekście zaprezentowano działalność Centrum Informacji Biotechnologicznej.

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