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FINAL REPORT ON UNIDO PROJECT:

"Strengthening and International Networking of Institutions in Developing Countries to Promote Mushroom Biotechnology and Bioconversion Technology for Sustainable Industrial Production and Processing, Phase I"

UNIDO Project XP/GLO/93/111 - UNIDO Contract No. 93/259/IR

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EXECUTIVE SUMMARY AND CONCLUSIONS

Establishment of an International Network of Institutions in Developing Countries to Promote Mushroom Biotechnology and Bioconversion Technology for Sustainable Industrial Production and Processing (working name: MUSHNET) is feasible and useful. While the primary focus and motivation clearly revolves around developing nations, the MUSHNET will require interaction with, and supplementation by, resources found in developed nations.

The establishment of the CUHK as an International Deposit Authority under the World Intellectual Properties Organization is potentially desirable. However, after study of the requirements, the conclusion was reached that this effort should be a separate initiative from establishment of the MUSHNET. The same categorization applies to the establishment of the CUHK as a resource center for research, development and training in mushroom biology and commercialization. The facilities planned by the CUHK for these purposes are quite satisfactory but not in place as yet. Bionomics International supports and recommends the establishment of such a center at CUHK and will help in any appropriate way requested.

The staff of the CUHK, Prof. S. T. Chang and Dr. J. Buswell, who will direct CUHK participation in the MUSHNET project, are recognized world-wide as experts in mushroom culture and applications. They have considerable information and personal knowledge on applications and marketing of mushrooms throughout the world. Thus, they are extremely well suited to provide subject matter guidance to designing and initiating the MUSHNET.

Extensive conversation and planning dialogue led to the mutual conclusion that the subject matter knowledge of the CUHK senior staff will require supplementation in the areas of information management, computer technology and electronic networking. The recommended supplementation would be accomplished through a combination of enhancing CUHK capabilities through adding staff at CUHK and consulting and operational aid from other organizations.

The overall policy for the MUSHNET would be set by a Steering Committee with representation from three areas: administrative, technical and user communities. Strong representation by the user community was agreed to be critical to success of MUSHNET. Thus, the restructuring of the current Steering Committee was agreed.

Professor S. T. Chang and Dr. J. Buswell would supervise at least one Information Officer, with subject matter expertise, in construction and updating of core databases installed as part of the MUSHNET. Information for incorporation of these databases would be gathered from a variety of sources. As the sophistication and capabilities of the MUSHNET grow, specific

databases would be constructed and housed on computers of cooperating nodes.

The CUHK has the expertise and interest to provide oversight and responsibility for content of the core databases to be made available through the MUSHNET. The computer facilities of the CUHK are excellent with respect to local area networking and international communication (through INTERNET). The central computer facilities of the CUHK do not provide a database host service. Further, the computer equipment provided to the CUHK for use in MUSHNET will not act as an international database server.

Consequently, the agreed database management process would be that CUHK would construct and maintain core databases. The databases would be electronically transferred to an international database host on the INTERNET (several are possibilities). The installation and maintenance of the publicly accessible versions would be the responsibility of Bionomics International (through use of fee-for-service collaborators). These services would be rendered by experienced personnel already in place. This process is technically efficient and cost effective. Since the services would be performed on an hourly fee and as needed basis, the hiring of a data technician would be avoided.

A series of nodes both in developing countries and developed countries are recommended to be components of MUSHNET. The various nodes would be either general in nature or have special expertise or resources. Node functions would include gathering of information for local and/or global use, acting as a conduit for information to and from the "central" node, dissemination of information to end users, train end users in MUSHNET use and triage inquiries with active subject matter interpretation for and to end users.

A partial relational model of the universe of information for inclusion in the network databases was presented and approved. Modification and amplification of the model is expected and required. The appropriate modifications largely will evolve as the design and implementation of MUSHNET proceeds.

Examples of information which could be provided to end users were discussed and analyzed. These examples included information gathered by Prof. Chang and by Bionomics International. These information sets were deemed appropriate for inclusion as MUSHNET information resources. One kind of information that was rejected for central collection and dissemination is comprehensive phenotypic strain data. However, the nodes would be encouraged and trained to establish internal computer databases of such data. Inquiries that required interrogation of such data for successful responses would be referred to the appropriate node for answering. This model implies a central "catalogue" database describing the holdings of each collection to the degree necessary for intelligent distribution of the query.

Further, there was discussion and consensus that multiple pathways and mechanisms for gathering, entering and disseminating information must be used in MUSHNET activities. These include converting paper records contributed by nodes, surveys and questionnaires, literature searches, adapting existing electronic databases and using creative approaches such as eliciting the cooperation of commercial attaches of the embassies in Washington.

INTRODUCTION

This document is the submitted as the final report for UNIDO Project: "Strengthening and International Networking of Institutions in Developing Countries to Promote Mushroom Biotechnology and Bioconversion Technology for Sustainable Industrial Production and Processing, Phase I". Phase I consists of two components which are 1) Network System Design and 2) Information Gathering Related to Mushroom Biotechnology. This report contains a summary of these efforts and examples of the products of the work. The full design and database will be held by Bionomics International (with a copy supplied on request to Dr. Virginia Campbell, Biotechnology and Genetics Engineering Unit (BGE), UNIDO, Vienna) pending delivery and installation of the UNIDO-funded computer equipment at the Biology Department, Chinese University of Hong Kong (CUHK).

The methodologies used to perform the tasks included:

=> Correspondence and telephone conversation with BGE, UNIDO to set the parameters of activity

=> Correspondence with CUHK to plan site visit and raise planning issues for discussion

=> Development of a partial relational model of the universe of information for inclusion in the network databases

=> Establishment of data gathering activity resources to supplement the resources of CUHK (Bionomics International and Microbial Strain Data Network (MSDN))

=> Computer searches of public databases

=> A site visit to CUHK by Dr. Micah I. Krichevsky for discussion, analysis of resources required, available and needed for establishment of the network.

Details on these methodologies and the results of their application are the subject of the report. The recommendations contained herein resulted from conversation with Prof. Chang, Dr. Buswell, and Dr. Campbell. Many of the recommendations have the concurrence of all. However, there are observations and recommendations that have been added by Bionomics International after the discussions. Therefore, the aggregate represent the opinions of Bionomics International and should not be considered as binding on either the CUHK or UNIDO.

PRELIMINARY COMMUNICATION

A site visit to Hong Kong was called for under the terms of the statement of work provided by UNIDO. In anticipation of this visit, communication took place with the staff of CUHK. In the

course of these communications, Bionomics International raised various questions and provided advice on the specifications for a computer system appropriate to the stated objectives of the Project.

Questions:

In preparation for my trip to Hong Kong, I have some observations and questions on the plans for constructing the Network. Clearly, you will not be able to answer all of these questions prior to my arrival in Hong Kong. However, I believe it will be useful for you to think about these items in preparation for our meetings.

The documents I have been provided by UNIDO indicate that the ultimate plans are to construct a world-wide network of "mushroom" collections, with emphasis on those in developing nations, that can provide strains of potential commercial importance. Further, this network is to be coordinated by personnel at the Chinese University of Hong Kong (CUHK). This message means to elicit the views of the persons involved at CUHK on the construction of the network.

First, and most important, do you intend that the network will be a true electronically mediated network?

Will the network, no matter how operated, be PRIMARILY a Special Interest Group (SIG) trading messages on matters of common interest? (This is the fundamental purpose of any network regardless of what else is accomplished by the network.)

Which taxa of fungi will be included in the areas of consideration of the SIG?

In addition to forming a SIG, what other services/capacities will the network provide when fully functional? Some possibilities are:

- training in network use,
- training in use of computers in culture collections,
- services in construction of collection catalogues,
- construction of a "super-catalogue" of holdings of network nodes,
- help desk on use of network services,
- help desk on searching world's electronic databases on

request,

- development of standards special to mushroom collections,
- lists of consultants on establishment and running of collections,
- construction of databases in addition to those listed above,
- etc.

In addition to the computer equipment discussed in my previous message to you, what other computer-related capacities are available to the Network in the Department of Biology and the CUHK?

Is the CUHK on Internet? APC, Fidonet, UUCP, Compuserve or other international electronic network? If yes, what address(es)?

Do you have a list of organizations who would be initial members (nodes) of the Network? What are the communications capacities of each? What computer capacities are available at each node?

Assuming an electronic network is the aim of the effort, what personnel at CUHK will be available for management of the network? What is their training? Will one be the System Operator (SYS/OP)? What part of their time will be devoted to this operation? Will you need outside help and/or shared responsibility (e.g., from MSDN)?

Where will databases be constructed? hosted? Who will pay for database construction?

The question of financing an international network is a complex one. Most governmental and intergovernmental funding agencies are reluctant to take on the task of long term funding of networking and database construction. Most of the UN system is an example. Therefore, you will have to have a "business plan" in place for long term funding. The main sources of funds that come to mind are:

- local funding (e.g., CUHK),
- various granting agencies (other UN agencies, governmental aid programs such as USAID),
- international NGO funding groups such as foundations, industrial organizations (mushroom growers associations,

etc.),

- fees for services rendered (training, consultation, etc.),
- fees for database and network access,
- subscriptions to catalogues,
- sales of stock cultures,
- etc.

Many of the items in the above list implies collection of fees.

This leads to other questions.

Who will manage subscriptions and/or billing for access and/or sales of information, stock cultures?

Will membership (node status) cost?

In general, if MUSHNET is to have a cost recovery aspect, who will pay? For what? To whom?

Computer specifications suggested:

I would advise an IBM-Compatible computer. The brand is not important. However, if you investigate what your colleagues in the University buy and find reliable and get good service on, I would suggest you follow that lead. If you send me a list of possible brands, I will try to comment on them. Of course, the brand names may be quite different even if they are the same computer.

The minimum characteristics I would advocate are:

IBM-compatible 486 computer in tower case with the following installed:

8 meg RAM (16 would be nice)

340 meg hard disk (larger if possible)

5.25 in. HD floppy drive

3.5 in HD floppy drive

tape backup drive (cartridge)

non-interlaced 14 in. vga or super vga color monitor, .28 dots

1 meg video memory

mouse or trackball (I prefer mouse)

If a LAN is available to you, you will need a network card installed. The nature will depend on the particular kind of network.

Hayes compatible External fax/modem - 14.4 baud with v3.2 and 4.2 error correction (should come with software for operation of both modes). Many advertise such compatibility but be careful as there is variation in the degree of compatibility.

Laser printer, Postscript capable (I have a HP 4M) I suggest something comparable. Get at least 4 meg ram.

The various connecting cables and interface boards that may be needed. Be sure to ask what is needed in each case.

(In the USA, the above should cost less than $7,000.)

Software (some may be included with the computer):

MS-DOS version 5 or 6

Windows 3.1

PC Tools 8.0 for Windows

Word Perfect 5.2 or 6.0 for Windows

Borland Paradox for Windows

Borland Quattro Pro for Windows

I will bring the Microbial Information System (Micro-IS) with me.

With the above questions in mind, extensive discussion of the establishment and operation took place at the CUHK on November 19 and 20, 1993. The rest of this report summarizes those discussions and further observations and recommendations from Bionomics International.

ANALYSIS OF RESOURCES AVAILABLE/REQUIRED

The restructuring of the existing Steering Committee was discussed. Consensus was reached that a new Steering Committee should be constituted. The present Steering Committee was deemed to be too narrow in disciplinary scope as well as too large to

function efficiently. The following outline summarizes the results of the discussion as well as some additional considerations.

I. Steering Committee for MUSHNET

A. In order to ensure that the MUSHNET is designed and operates properly, a Steering Committee establishes, in sequence:

1. functionality specifications

2. resources required

3. resource distribution criteria and procedures

4. operating procedures

5. operations evaluation criteria and procedures

B. Steering Committee Composition

1. Voting Members

a. Users: The actual community of users must be represented strongly in decision making on both design and operations policies. Without this representation, no such service will succeed.

b. Administrators: Persons responsible for funding and administrative decisions and support must be represented at all phases of decision making as it is this group is responsible for providing the necessary resources.

c. Computer and Information Specialists: The specialists have responsibility for the technical aspects of the MUSHNET. They must present the rest of the team with realistic and efficient technical proposals.

2. Chair: The Steering Committee should always be chaired by a member of the users' group to ensure that the users are first among equals in one direction and to ensure user commitment to MUSHNET in the reverse direction.

II. MUSHNET Secretariat at CUHK

The personnel at the CUHK are Professor S. T. Chang and Dr. J. Buswell. They are extremely well qualified to provide subject

matter guidance to the MUSHNET. Because of other commitments as faculty members of CUHK, they could not be expected to devote full time to the MUSHNET day to day operations. Therefore, they would supervise at least one Information Officer, with subject matter expertise, in construction and updating of core databases installed as part of the MUSHNET.

A. Personnel

1. At least one full time staff person should be charged with initiating the network as Information Officer. Soon after startup, staff support of at least the equivalent of a second person will be needed as a Data Technician/Clerk Typist.

2. Job Descriptions

a. Information Officer

(1) The Information Officer should be experienced at the B.S. or M.S. level. At least five years work experience in mycology is more important than detailed knowledge or experience in computer technology. The Information Officer should have some previous experience with computers sufficient to demonstrate the capacity to learn. The Information Officer will be expected to learn through on the job training. Knowledge of English is required for international communication.

(2) Technical Network Management: Approximately 25% of the time will be spent in managing the Network itself. The electronic addresses must be assigned. Address directories must be constructed. The directories must contain routing information for those not available through the Internet system. System use documentation must be adapted to the changing needs of the network. System user questions must be answered. (Unfortunately, users often do not consult even the best documentation.) Databases must be transferred to the those responsible for managing the databases on the computer hosting the public versions of the databases. Moderators for computer conferences and bulletin boards must be found and

trained. Notices of new or changing system features must be disseminated.

(3) Database construction: Another 25% of the time will be spent in constructing or adapting databases. Some of the databases will be established and maintained by other organizations. These would require none of the time of the Information Officer other than to notify users of availability. Many of the others are specific to this project. They will have to be constructed de novo. Updating of the databases will be a continual process, especially in the case of bulletin boards which contain a great deal of date dependant material.

(4) Network Services: The Information Officer will spend the remaining 50% of the time in interacting with the Network membership to answer disciplinary oriented queries, organize procedures and consultants for the "help desk" services, develop and disseminate publicity on the system (which will only succeed as people know about it), develop expanded services, establish and maintain collaborative relationships with other organizations, and develop an expanded network membership.

b. Data Technician/Clerk Typist

(1) The Data Technician/Clerk Typist should have standard typing skills as well as some experience with computer word processing and/or keyboard data entry. Knowledge of English is required for international communication.

(2) The Data Technician/Clerk Typist will provide ordinary clerk/typist support to the senior staff of the CUHK MUSHNET node (Chang and Buswell). Under the supervision of the Information Officer, the Data Technician/Clerk Typist will enter information into the computer for incorporation into MUSHNET databases.

III. Equipment

The initial computer required by the CUHK was described above. This computer is on order pending final clearance by UNIDO for purchase. The computer would be primarily used by the Information Officer. A second computer, which could share some of the facilities of the first, is recommended for use by the Data Technician/Clerk Typist.

The CUHK is installing a Local Area Network (LAN), connected to its central computer center throughout the campus. This system will be available to MUSHNET-CUHK. Conversation between M.I. Krichevsky and a technical representative of the CUHK computer facility clearly indicated that the CUHK was being equipped with state of the art LAN capabilities. Further, the central computer system was directly connected to INTERNET through a high speed line to NASA-Ames in the USA. These capabilities will allow MUSHNET-CUHK to communicate very well with the world's networks. The central computer facility has a user support group that will aid the MUSHNET-CUHK in using the facilities. Dr. Buswell was supplied with the name of the contact person in the user support group.

The hosting of MUSHNET databases for public network access cannot be done either on the computer being purchased for internal use or on the CUHK central system. The internal computer is not powerful enough to act as an international database server. It cannot provide access to multiple users of the databases. Further, the management and backup of such a system is beyond the expertise and time available from the projected Information Officer.

As a matter of policy, the central CUHK computer system is not available as a host either. While this system is available as a very fine communication mechanism, other facilities will have to be located to host the final databases. Thus, another organization should provide database hosting and gatewaying support to MUSHNET. Bionomics International could provide this support in a cost effective manner. The details of the recommended support mechanism are described later in this report.

Bionomics International recommends that the primary carrier of electronic communications for MUSHNET be the INTERNET. This system is the largest international network in existence. However, many persons, especially in developing nations either cannot connect to INTERNET or find it prohibitively expensive to do so. (The CUHK central facility provides INTERNET services to the campus at no charge. However, some other institutions pass back the costs to end users.) Alternate communication paths must be established and used. The technical aspects of developing such paths should be done by the same organization alluded to in the previous paragraph.

The above implies two interrelated topics of technical support: communications paths and database access. The communications path of INTERNET should be supplemented by connection to, and collaboration with, ICGEBnet (on INTERNET), the Association for Progressive Communication (including ECONET and GREENET), the

Microbial Strain Data Network, FIDONET, etc.

Potential database hosts would be ICGEB, MSDN, a MUSHNET node in Thailand, etc. Many of the databases would be appropriate and desirable for installation on multiple hosts to ensure the widest possible dissemination.

CONNECTIVITY

In the last decade an explosive proliferation of entities named as networks. They range in complexity from simple associations of people or organizations with stated common purpose to high technology, automated, linked computer based nodes communicating at high rates and high costs. The following discussion is confined to networking schema that are electronically linked. Further, it omits any detailed consideration of analogue linkages such as television even though much of this communication is or soon will utilize wide band digital technology as well.

No single scheme of digital networking will reach all concerned with mushroom cultivation for the foreseeable future. We must accept the caveat that the foreseeable future likely is no more than five to ten years.

Three main schemes are likely to carry the vast majority of digital network messages related to mushroom cultivation: Packet Switching with gateways to distributed hosts, message forwarding, and direct computer to computer connection. Further, all of these schemes can be and are interconnected at some level of utility.

Packet Switching Systems. The Packet Switching Systems (PSS) operate through a series of interconnected computers, scattered within and throughout at least two thirds of the countries of the world. Within at least those countries, entering the network from any computer equipped with a modem and communications program allows global communication by a simple telephone call to the nearest entry point. The local computers providing access are informationally passive, serving only to establish and maintain the connection to the remote host computer. The network itself usually is centrally operated and controlled. The interactions with the host computer are fully interactive.

PSS systems allow any individual to utilize the services from any location with a telephone connection. All that is required is the proper authorizations including passwords applicable to the particular entry point. The equipment costs are quite low. As indicated above, any personal computer with a modem will serve.

The Omnet network of oceanographers is an example of this type of network scheme. The strengths of Omnet are its use by a large proportion of the world's oceanographers, its electronic mail and its large number of computer conferences.

In microbiology, the Microbial Strain Data Network (MSDN) service was based on the PSS approach. Interconnection through a gateway provided interconnection to the Internet system which is a message forwarding scheme. Currently, the MSDN uses Internet directly while still allowing access through PSS gateways.

Message Forwarding. Message Forwarding systems are decentralized networks wherein each participating organization agrees to pass messages on to the next organization in the network. The computers must be capable of multitasking. Thus, the individual user connects to the network through a specific institutional computer. Thus, it is the institution that joins the network and bears the cost of joining.

Here each computer on the system can, and usually does, act as an informational host as well as a connection point. In the earlier and lower speed implementations of this design (e.g., BITNET), the messages are always batch transmissions. If a remote database is to be searched, the instructions for the search are contained in the message itself. The results of the search are placed in a response batch message. In the latest implementations of this general scheme (e.g., INTERNET), high speed connections make it practical to connect directly into the remote computer.

Many academic institutions around the world participate in these message forwarding networks which are linked through the INTERNET scheme. Other kinds of institutions are joining as well. To the individual users, especially in larger institutions view the costs as small or "free". In fact, the costs per institution can be considered large when the cost of high speed dedicated lines and the computer facilities are taken into account. Increasingly, the charges for use are being passed back to the end user.

The smaller the institution the more difficult the funding of the necessary infrastructure for full use of the INTERNET type of system. However, for the purposes of simple electronic mail and batch use of such systems, the message forwarding systems can be quite cheap as they do not require dedicated lines and can be operated sporadically (say ten minutes of every hour) to keep long distance telephone charges low.

In general, the services we take for granted at low cost in the most developed nations are much more expensive in both relative and absolute terms in less wealthy nations. This fact must be a fundamental part of any networking design in the area of mushroom cultivation in developing nations.

Computer to Computer Over Voice Grade Lines. This model uses ordinary dial up telephone lines and high speed modems with error correction to compensate for noise on the line. For example, calls take place at intervals (e.g., once daily between the UK and Senegal). The name of the program used is FIDO and the

implementation is FIDONET.

Interconnections among the Systems. Interconnections among the systems exist and are usable. The simplest and cheapest to accomplish is electronic mail messages. Mail gateways now are commonplace between commercial PSS systems and INTERNET networks. Less common are full service interactive links but these too exist. The APC provides interconnection services among all these systems.

Another view of gateways and connectivity is provided by the MSDN. Here the emphasis is on access to a wide range of databases which can be searched interactively. The MSDN provides electronic mail, bulletin board and computer conferencing as well as database access. It was established to focus on microbiological strain data. Since its beginnings a wide range of information has been made available through a combination of developing a database host system in collaboration with the BDT as well as direct gateways to a number of computer systems on four continents. These data sources can be entered either through the PSS or INTERNET pathways.

The overall conclusion is that the technology exists to develop bidirectional communication among any of the existing digital networks. Given the funds and access to the proper expertise, any mutually agreed connection could be established and may well have been done already. Indeed, digital radio and satellite technology exists which can solve the connectivity problems to the remotest areas of the globe and at attainable costs.

MUSHNET NETWORK SERVICES

The MUSHNET could provide the following recommended services to the member nodes and to the relevant scientific community. Each will be discussed in turn.

Email/File Transfer: As described in the previous section, digital electronic mail (Email) can be accomplished through a variety of pathways and carriers. Many of these alternatives will have to be used in concert to reach the maximum number of appropriate nodes (members) of MUSHNET. The current state of the art of digital communication is such that almost all conceivable nodes will be able to communicate at the level of Email. The minimal requirements are a personal computer, a modem, and access to a telephone line. Such communication can be made to work even in countries with poor grade (noisy) telephone lines (albeit with some degradation of service and considerable frustration for the user).

While such communication is conceptually simple, the neophyte user is often intimidated by the variety of addressing schemes that must be mastered. Overcoming this cultural lag must be a function of the Network technical administrators. Bionomics

International recommends that this training and management function be performed by the MSDN coordinated through Bionomics International. Funding of these services would be on a fee for service basis rather than a retainer basis. Thus, only those hours necessary to perform the actual service would be a cost. This would avoid the necessity to employ and train a full time system manager.

Acquire Databases: CUHK personnel would acquire databases for dissemination to the nodes of MUSHNET and the interested scientific, technological and general communities. These efforts would start with the conversion into machine readable form of the considerable amount of information amassed by Prof. Chang.

A second source of databases would be the various nodes. These databases would be those that the nodes would contribute for central installation and maintenance by the Secretariat. (In a personal communication, Dr. Jong of the Mycology Department of the American Type Culture Collection (ATCC), logically a key node in MUSHNET, has indicated that he would be willing to make available information that he has collected over years from literature sources.) Other databases of the nodes would remain with the nodes (see "Establish Links to Databases At Nodes", below.

Online databases would be searched for further information, e.g., patents relevant to mushroom cultivation and commercial development and use. This last function could be performed by experts in database searching in the MSDN as well as in the Bioinformatics Department of the ATCC. Non-traditional methods of information gathering, especially on commercial growth, consumption, trade, etc. of mushrooms around the world, would be gathered by Bionomics International through its considerable contacts within the diplomatic community of Washington, D.C. The embassies of the various countries almost all have commercial attaches who will usually respond to specific marketing questions about their countries.

Other sources of databases are the bulletin boards and computer conferences that will be established by MUSHNET or that will accessed by MUSHNET users. These can be edited and transformed into more classic databases and publications. However, the history of such bulletin boards and conferences is varied. If they are undirected and facilitated by an editor (often termed a SYS/OP) on a current basis, they usually start with a flurry of interest and degrade to occasional contributions such as notices of studies and seeking employment opportunities. (Please note that such contributions do have a place on networks. They do not by themselves justify a network.) One of the recommended roles of the Secretariat would be to appoint/locate SYS/OPs for the various bulletin boards and conferences.

Prepare (Edit) Databases for Network Use: Databases will be installed on one or more database servers under the editorial

control and be the responsibility of the CUHK Secretariat. These may contain material that has limited access or appeal, i.e., for use only by the MUSHNET nodes. Alternatively, MUSHNET will construct databases that have wide public appeal. In either case, the policies governing the appropriateness of the databases and the rules governing access should follow policies agreed by the Steering Committee. The final contents of the several databases would be decided and produced by the CUHK Secretariat, irrespective of the initial source of the information.

The CUHK Secretariat would transform paper records or already machine readable information into one or more formats suitable for public access. Internally, most of these would be relational databases (e.g., using the Paradox program) for ease of maintenance and use at CUHK. The information would be transformed by mapping into whatever format is most suitable for public searching. This format(s) would be decided by choosing from those available on the selected public host(s). Commonly, these formats are flat files. The process of conversion from Paradox to a flat file format is simple and should present no problems. The report generation capabilities of Paradox should suffice.

Install databases on host(s): The final installation of the databases on the public host(s) should be done by an external organization with experience in these techniques. This is recommended for three reasons. 1) The computer facilities acquired for use by CUHK for MUSHNET are not adequate to act as a public database server, nor would it be cost effective in funds or personnel to upgrade to the required level. 2) The central computer facilities of the CUHK are not available as a policy to host public databases such as those for MUSHNET. 3) Specific staff would have to be hired for the purpose. This would represent an undue cost in salary, fringe benefits, overhead, and space to duplicate what can be obtained elsewhere on an as needed basis for much less total cost. Bionomics International recommends that this function be performed by the MSDN coordinated through Bionomics International. Funding of these services would be on a fee for service basis rather than a retainer basis. Thus, only those hours necessary to perform the actual service would be a cost.

Maintain (Update) Databases: Once created, databases should be updated with current information. These updated versions should be made available to the potential users as frequently as sufficient new information is gathered to be useful. The rate of accumulation of new information usually will dictate an update in the range of monthly (new articles in journals, patents) to yearly (yearly market trends).

Establish Links to Databases At Nodes: There will be databases, developed by the various nodes, that are impractical or undesirable to be installed on a central host. There are various reasons for this: administrative permission is lacking to release the database,

the cost of transforming the database into a common format or making it machine readable is prohibitive, the database contains proprietary or other non-public information so the node wishs to have absolute control over searches (see "Triage Questions (Help Desks)" below), etc. These databases may be linked by computer gateways or surrogate searching by node personnel.

Establish Links to External Public Databases: The databases freely available to the public (but not necessarily free of cost) include a great many of potential interest to MUSHNET users. These include MEDLINE of the U.S. National Library of Medicine, the databases of the U.S. National Agricultural Library, DIMDI, databases of the CAB, various patent search services, MSDN, World Data Center on Microorganisms, ATCC, DSM, etc. Of special note as genetic engineering of mushrooms takes place and may lead to planned or inadvertent release of the modified organisms into the environment, will be the IRRO and BINAS systems. IRRO and BINAS are designed to cover complementary aspects of the regulations and risk assessment of release of "exotic" life forms into environments.

These links can be established for MUSHNET by the MSDN since this organization has considerable experience in developing such links. In fact, a number of the links already exist.

Triage Questions (Help Desks): With occasional exception, one would not expect that scientists who have devoted their professional careers to the study of mushrooms to be computer literate beyond simple word processing. Further, if a large proportion of such individuals were adept at, and facilities for, international electronic messaging and database searching, MUSHNET would already exist. Until such time as the knowledge and facilities required for global interaction among those interested in mushroom studies and commercialization there will be the need for intermediates who can provide links for those not able to fend for themselves.

A series of "help desks" is recommended for this purpose. They would be located at selected MUSHNET nodes. The personnel at these help desks would know effective paths of routing questions and finding information. To do so, they must know the elements of the overall MUSHNET system and have subject matter knowledge of mushrooms. Locating information to answer a specific question often is greatly dependent on correct scientific interpretation of the question and knowledge of the contents of available databases.

A simple example is that the searcher should know what genera are included in the rubric "mushroom" to know whether a culture collection's mycological database is likely to contain answers to questions about edible mushrooms. The collection database is more likely to be structured along strictly formal taxonomic lines than by the common names such as "edible mushrooms". The help desk person would already have some knowledge of what collection databases were available for searching.

Such a service becomes especially important to those MUSHNET nodes that are not directly connected to high speed digital communication facilities which allow personal interactive searching. The help desk concept would enable such searching even if the initial contact by the questioner was through spoken word or ordinary mail.

Training (Technical and Subject Matter) in Network Use: There are two barriers to acceptance and maximizing use of electronic networks by neophyte users. The first barrier is the problem of how "user friendly" is the network to use. In the ultimate sense, the concept of user friendliness does not exist. Another term that is used is "intuitive". An international network such as MUSHNET is targeted at a population of users that is not inherently computer literate. In fact, many of the desired users may approach computer usage with some reluctance and apprehension. The "user friendly" systems seldom come with a tutorial on how to turn on the computer and what to do before entering the network domain of the system. Often, two or three different manuals and some precedent colleagues must be consulted to get started. Thus, success of the MUSHNET has as one of its requirements, the minimizing of this learning threshold for the beginner.

The second barrier is the accessibility of the subject matter or contents of the information base and information technology that is specific to the MUSHNET user. Basic Boolean algebra, used in searching databases, must be taught to many of the users. Computer management of their own data would be most usefully imparted to users. This last would make acquisition of information for use by the network as a whole considerably more efficient than placing the total burden for database conditioning on the Secretariat.

Thus, considerable effort should go into education of users. The first step in establishing an educational component in the MUSHNET is the training of Secretariat staff in networking operations as well as in computer data management of microbiological information. Bionomics International recommends that the Information Officer be sent to two locations for cooperative training: Cambridge, U.K. (MSDN) and Rockville, MD, USA (Bionomics International). The reason for both venues is that each has its specialty. MSDN can impart excellent experience in network management. Bionomics International would give training in database design and computer analysis of microbiological information. Since Bionomics International is located in space rented within the ATCC, and cooperates closely with the ATCC staff, the Information Officer would be exposed to modern computer management of collection information. For example, Bionomics International personnel periodically have published the results of a continuing collaboration with the Mycology Department on computer coding of phenotypic data describing fungi.

Produce Training and Informational Material on Network Use and Services: Training courses and user manuals must be constructed for the education of user. The materials must be targeted to the level

of neophyte user anticipated.

Many aspects of such a course (and appropriate training materials) are covered in the UNEP-sponsored courses, largely held in developing nations, on "Computers in Microbiology". The course materials and the faculty for these courses were developed and are maintained by MSDN and Bionomics International. Bionomics International recommends that a course and tutorial material be adapted for use by MUSHNET using the UNEP course as a model. Further, we recommend that a specific budget and personnel item for training and course material development be built into the MUSHNET.

Initiate and Maintain Liaison with Other Networks: In addition to external information resources, MUSHNET users will want to participate in other networks. Through the triage system described above, the Secretariat and the various nodes can inform users of appropriate networks. Some examples are: MSDN (culture collections), IRRO and BINAS (release of exotic/engineered organisms), ECOnet, GREENnet and BIN21 (biodiversity). There are many others accessible through INTERNET and the Association for Progressive Communications (APC). For example, the MSDN is cross listed on the selection menus of ECOnet and GREENnet so users can go among them. The Secretariat, with the help of the MSDN Secretariat could establish such agreements. It would then be the role of the MUSHNET Secretariat to inform and help users in accessing these supplementary networks.

Data Backup Services: Because of the existence of file transfer protocols as well as the ability to store large amounts of data on floppy disks and tapes, the Secretariat could provide a service of acting as a repository of data for the nodes. This service would be for the purpose of providing off site backup for valuable data. Such off site backup is often neglected by new users of computers. Once a large amount of valuable data is lost, the new user often becomes a convert (too late) to the value of backing up the computer. In any case, the Secretariat should have arrangements for frequent backup of their information as well as storage of a set of the backup tapes at an off site location.

Consultation in Computer Management of Collection and Laboratory Data: As computers are introduced into mushroom collection management, help in effective utilization of these techniques will be useful and welcome by the collection managers. Bionomics International strongly recommends that the Secretariat of MUSHNET receive training in these skills to enable staff to train and answer questions from the various nodes. The skills involved include acquisition, management, and analysis of laboratory data, numerical taxonomy, statistical measures of biodiversity, and sequence analysis. To initiate this process, the Micro-IS programs were installed on the computer of Dr. Buswell. These programs serve a different purpose, that of managing primary phenotypic observation strain or species data, than either the Paradox program

(relational data base manager, useful for secondary information derived from laboratory data), Quattro Pro (spreadsheet, useful for managing numerical data such as budgets). The Micro IS is being used for building future Bergey's Manuals by computer, managing strain data in a number of collection collections including in China, Russia, ATCC, etc.

Since the Micro-IS is freely distributable for scientific purposes, the Secretariat could distribute the programs to the nodes for use in collection management. The use of these programs constitute a significant part of the aforementioned UNEP-sponsored course on "Computers in Microbiology".

Publicity: MUSHNET should be publicized widely to have maximum effect. Various mechanisms could be used. Posting notices on the various bulletin boards on the networks mentioned above should be done. Organizational newsletters should have articles inserted. These include the newsletters of such organizations as the World Federation of Culture Collections, the newsletters of the various national and regional Federations of Culture Collections, publications of the International Union of Microbiological Societies, the ASM News (circulation about 50,000), etc.

MUSHNET should establish its own printed newsletter to publicize its activities and services both to users and to the interested community at large. A main use of the newsletter would be for information on use of the MUSHNET as the network evolves. The newsletter could also publicize node activities and opportunities for collaboration. An electronic version of the newsletter would be a useful database on the MUSHNET.

INFORMATIONAL UNIVERSE OF MUSHNET

The study, cultivation and commercial exploitation of mushrooms relates to a broad range of informational categories. No one network realistica lly could expect to collect and curate all the possible desirable information. The relationships among the informational domains, recommended for the MUSHNET, are summarized in the simplified relational model appended as Figure 1. This model omits many of the possible connections and the fine structure of the domains in order to maintain readability. Some of the categories of information and the organizations that likely would curate the information are (Note that the following is meant to be exemplary not ccmprehensive):

MUSHNET Secretariat: Methods (laboratory and scale up), Applications of mushrooms, Experts (consultants), Funding sources, Training opportunities, Marketing information, Culture collections of mushrooms, Linkages to nodes, Linkages to external organizations and information sources, User manuals, Bulletin boards, Computer conferences, Tutorials on MUSHNET use, etc.

MUSHNET Nodes: Strain information, specific collection information, Inventory of holdings, research, development projects, catalogues External Personnel/Organizations: Bionomics International has made contact with a number of organizations who could contribute to the establishment and operation of MUSHNET. In fact, Bionomics International has used the services of one of these (MSDN) to aid in the gathering of the data that will be supplied to CUHK for use in building databases. In addition to Bionomics International itself, these organizations include MSDN, ATCC, U.S. National Agricultural Library. The cooperation of IRRO and BINAS (both sponsored by UN agencies) is certain.

Of these organizations, Bionomics International and MSDN can provide operational support to the Secretariat of MUSHNET. Through the efforts of these organizations, links to other information resources can be established. The types of information include Intellectual property regulations and practices, Patent information, Biosafety information and regulations on food, drugs, and environment (of workers, contained growth, and release), biodiversity databases, biodiversity projects, supplementary funding sources and collaborations, etc.

DELIVERABLES

The following have been accomplished/delivered under the terms of this contract.

Site visit: A visit was made to the CUHK. In addition to the verbal consultation with staff of the CUHK and UNIDO, the Micro-IS programs were installed in the computer of Dr. Buswell. The results of that visit are covered in this report.

Design consultation: The correspondence between Bionomics International and the CUHK is summarized earlier in this report. In addition, extensive consultation was done with staff of UNIDO. The results of this consultation are summarized in this report. An overall structure/design for the MUSHNET is provided.

Information provision: (1) Bionomics International provided staff of the CUHK with the procedures and an example of a successful application for applying for status as an International Depository Authority. (2) Information on marketing of mushrooms and marketing organizations were tendered to the staff of CUHK. These are preliminary and reflect the effort at the time of the site visit. More extensive information, both as paper documents and in machine readable form, will be provided when the UNIDO-funded computer system is functional at the CUHK. In the meantime, this information will be held by Bionomics International for safe keeping under the backup procedures in force. Another copy will be supplied to the UNIDO Project Officer upon request.

POSSIBLE FUTURE MUSHNET/BIONOMICS INTERNATIONAL INTERACTION

The staff of CUHK are most assuredly expert in mushroom science and technology. Their expertise lies in this area and is critical to the success of MUSHNET. Without this expertise, subject matter network, of the type envisioned by UNIDO is impossible. However, they are lacking in expertise in constructing and operating an international network. Further, Prof. Chang and Dr. Buswell made it clear that they do not have the time to devote to the technical aspects of running such a network. Bionomics International feels that the level of expertise in subject matter they provide warrant location of the MUSHNET Secretariat at the CUHK.

Bionomics International stands ready to help with the technical aspects of MUSHNET design and inauguration. Working with collaborators such as the MSDN, Bionomics International would provide the following services as agreed by the MUSHNET Steering Committee and the CUHK Secretariat.

=> Design consultation

=> coordination of host site(s) for the databases

=> coordination of acquisition of specialized information to supplement those of the CUHK and the nodes, e.g., patents, safety regulations, import regulations, marketing and other commercial information

=> participate in design of training courses such as "Computers in Mushroom Biology and MUSHNET"

=> train MUSHNET and Node information officers

=> consult on functions of help desks and node responsibilities

=> coordinate extra-Internet communications (FIDONET, APC, etc.)

Bionomics International does not propose any long term operational role for itself in MUSHNET. Either MUSHNET will become entirely self-sufficient or it may choose to maintain an operational relationship with an appropriate organization such as the MSDN.

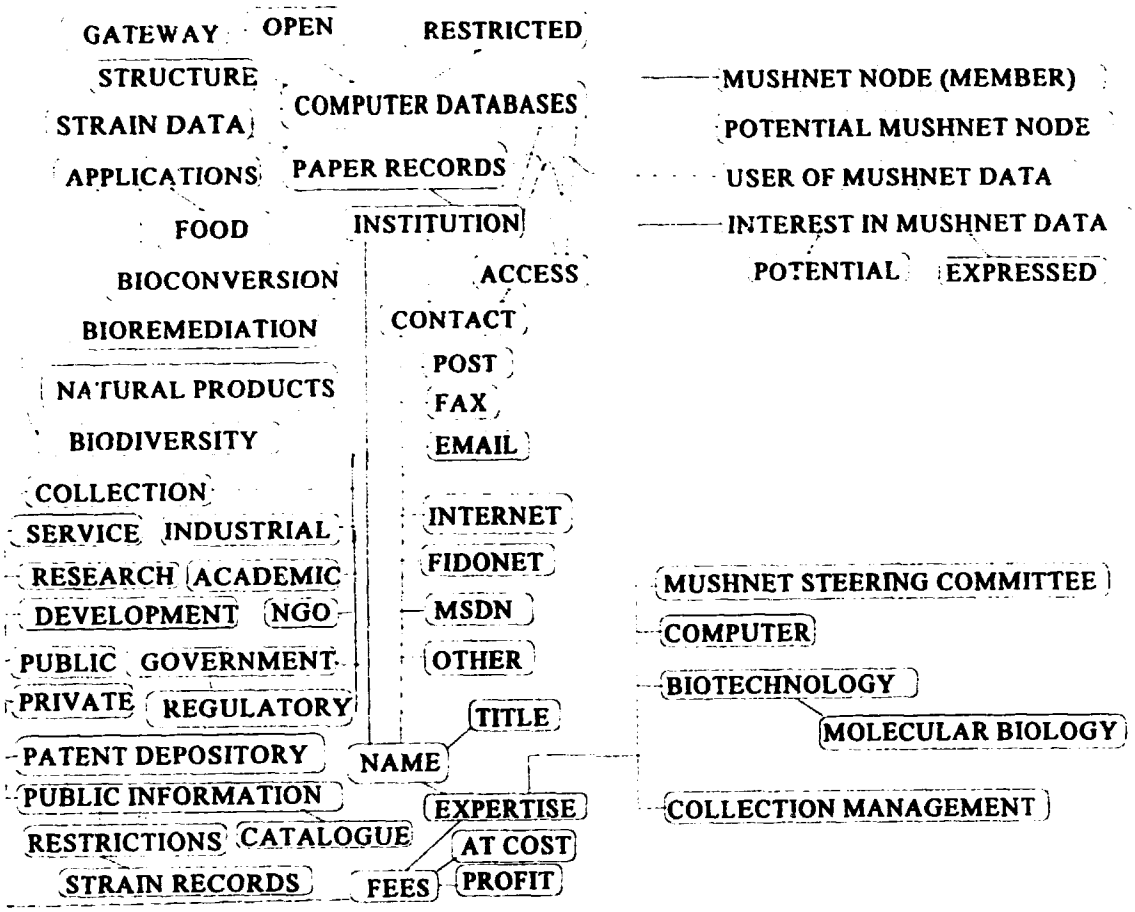

Figure 1. Initial Model of Informational Universe for Mushnet. Not all possible items or connections are shown due to complexity of problem.