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21464

26p.  
20. Jan. 6, 1995

02 JAN 1995

**Final Report on the MUSHNET Project**  
**(Strengthening and International Networking of Institutions in Developing Countries**  
**to Promote Mushroom Biotechnology and Bioconversion Technology**  
**for Sustainable Industrial Production and Processing, Phase II)**  
Contract # XP/RAS/94/135

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**December 8, 1995**

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## EXECUTIVE SUMMARY

Mushroom cultivation for commercial exploitation continues to increase rapidly. The world production of edible mushrooms doubled in the period 1986-1991, from 2,176,000 to 4,273,000 metric tons fresh weight as reported by Chang (in Chang, S.T., Buswell, J.A. and Chiu, S.: *Mushroom Biology and Mushroom Products*. The Chinese University Press, Shatin, N.T., Hong Kong).

The MUSHNET initiative originated in December 1991 under UNIDO's Industrial Development Decade for Development of Africa (IDDA) and a subsequent request to UNIDO from the Chinese University of Hong Kong. While the initial focus of MUSHNET is in Asia pursuant to the Terms of Reference, the concept is extensible and being extended to other parts of the world at a rate dependent on resources available and contributions in kind.

MUSHNET is a distributed network of cooperating organizations acting as network nodes with an interest in the biology, biotechnology, and commercialization of growing mushrooms for their intrinsic values in various categories. Thus, MUSHNET emphasizes subject matter which ranges from the biodiversity of mushrooms and related fungi, genetics, methods of cultivation, sources of cultures, processing, packaging, shipping, markets, marketing, regulations governing quality and safety, and quality control of all of the foregoing.

The basic design of the MUSHNET is complete. The first two nodes are operational. Bionomics International provides design guidance for the initiation of the MUSHNET. The Microbial Strain Data Network has developed an extensive database on sources of information available to the public in commercial and non-commercial computer databases related to mushroom cultivation. This database is being augmented with further exploration of the Internet. An international electronic mail discussion group will start on the MUSHNET in the last quarter of 1995. Other nodes projected to actively join the MUSHNET in 1995 are located in the Philippines, Thailand, India, and South Africa. These four nodes will act as initial regional foci for MUSHNET activities. Active discussions for participation are underway with organizations in Sri Lanka, Pakistan, Vietnam, Bangladesh, Russia, China, and Japan. Thus, during 1996, the nodes of MUSHNET will be balanced between information providers and distributors. Some nodes will function in both ways.

## I. INTRODUCTION

This Final Report provides an overview of the MUSHNET initiatives were carried out pursuant to the Terms of Reference of contract XP/RAS/94/135, for \$45,000 (Annex A.1) and \$24,000 (Annex A.4) with the Technology Services Unit of the United Nations Industrial Development Organization (UNIDO). Because of the intertwined nature of Annex A.1 and A.4, we are submitting a single Final Report to cover the two annexes.

Mushroom cultivation for commercial exploitation is a multi-billion dollar growth industry which continues to increase rapidly. The world production of edible mushrooms doubled in the period 1986-1991, from 2,176,000 to 4,273,000 metric tons fresh weight as reported by Chang (in Chang, S.T., Buswell, J.A. and Chiu, S.: *Mushroom Biology and Mushroom Products*, The Chinese University Press, Shatin, N.T., Hong Kong). Substantial mushroom biotechnology industry opportunities exist in Less Developed Countries (LDCs) for small and medium-sized enterprise (SME) and microenterprise development.

The MUSHNET initiative, i.e., the establishment of an informational network to support mushroom biotechnology and commercialization in developing nations, originated in the UNIDO's December 1991 Industrial Development Decade for Development of Africa (IDDA) "Expert Group Meeting on the Applications of Biotechnology to Food Processing in Africa" held at the International Institute for Tropical Agriculture (IITA) in Ibadan, Nigeria, which called for the initiation of an African mushroom biotechnology development effort. A subsequent, separate request was made to UNIDO from the Chinese University of Hong Kong to help establish an Asia-based mushroom biotechnology initiative. Pursuant to the Terms of Reference, the initial focus of MUSHNET is in Asia. However, the concept is extensible and is being extended to other parts of the world at a rate dependent on resources available and contributions in kind.

The principal focus of the MUSHNET planning and development effort is the incorporation of a global information resource and support network on mushroom biotechnology to facilitate and accelerate the environmentally-sound introduction and development of mushroom industries - small- and medium-sized enterprises (SMEs) - by LDCs. This scientific information resource and communications focus addresses a widely-shared concern among biotechnologists, LDC networks, and development experts. The following is a frequent observation: "the most critical obstacle to succeed in the generation and adoption of new technologies for small-scale producers is the absence of communication and cooperation between various groups and types of people whose contributions are essential: farmers, scientists, policy-makers, extensionists, and others in the private sector. Without effective exchange of information, it is possible neither to plan nor to coordinate the activities needed." (Joske F.G. Bunders, Jacqueline E.W. Broerse, et al. of the Department of Biology and Society, Free University of Amsterdam, in their article on "Choices and Dilemmas in Linking Biotechnology, Indigenous Technical Knowledge, and Small-Scale Production," in *Land to Lab: Biotechnology for Sustainable Agriculture in Asia - Proceedings of the first ANSAB Workshop, March 29 -April 1, 1992*. Edited by John Perchak and Sharmila Ribeiro. Washington, D.C., Appropriate Technology International, 1992, page 124.)

## II. ACTIONS TAKEN

**A. MUSHNET Node System Defined** - In accord with discussions with UNIDO, a concise description on the design of MUSHNET was prepared (See Appendix 1). It is presently used for dissemination to prospective organizations which could or are prepared to serve as node hosts for the network.

The brief description serves as an informational document for other organizations interested in participating in MUSHNET. It is also intended to serve as a draft brochure for consideration and improvements by a future Steering Group of the MUSHNET organization. Along with other information, the final brochure (to include the listing of MUSHNET nodes and the Steering Group) will be made available for direct dissemination to specialized organizations, as well as through INTERNET to a broader constituency of organizations likely to be interested in MUSHNET.

**B. MUSHNET Database Development of Mushroom Information Resources Commenced** - A series of mushroom database development activities have been carried out by the Microbial Strain Data Network (MSDN), Sheffield, UK.

These entail searching sources of mushroom information on the INTERNET and other networks, some commercial, accessible to the public. The resulting report (See summary in Appendix 2) identified a wide range of accessible information and networks in related areas. These varied greatly in terms of quality of scientific content and utility for either scientific research, or industrial development purposes.

Detailed searching for contact information in the various facilities and services available on the Internet resulted in well over a thousand e-mail addresses with specific interests in mushroom, truffles, and fungi. Notwithstanding this manifestation of broad interest in mushroom information, there are substantial gaps in scientific and technical subject matter as well as entrepreneurial and other economic development-related information. Scientific and technical subject matter information gaps include: biodiversity of mushrooms and related fungi, genetics, sources of cultures, spawn resources, substrates, fungicides and pesticides, and toxicology. Development-related information deficiencies include processing, packaging, shipping, markets, marketing, standards governing quality and safety, and quality control in general.

Among the accessible information resources are a few electronic networks that also have linkages to developing nations. There are a substantial number of on-line scientific databases and information resources directly pertinent to the development of MUSHNET. With exceptions (e.g., China, Brazil, and Russia) most of the latter are in the Western industrialized nations. The preponderance of such scientific data and resources is in the form of microbial culture collections (e.g., International Mycological Institute, U.S. National Fungus Collections databases, American Type Culture Collection); herbaria and botanical garden collections (e.g., Swedish Museum of Natural History Lichen Herbarium, Royal Botanical Gardens, at Kew, UK, and Real Jardin Botanico in Madrid, Spain); professional scientific organizations in related fields (e.g., International Society for Plant Pathology, Mycological Society of America), and University research facilities (e.g., Recife University, University of Wisconsin). While most of these "mushroom" resources are not focussed exclusively or even primarily on mushroom biotechnology, they do provide substantial information and access to expertise in both the subject matter, and economic development areas.

Unlike the considerable scientific information that is available on-line from, for example, the Centraalbureau voor Schimmelkultures (Baarn, The Netherlands) and the above-noted collections, the mushroom microbiology and biotechnology research and holdings of the Centre for International Services in Mushroom Biotechnology (CISM Biotech) at the Department of Microbiology, Chinese University of Hong Kong are not, at this point, accessible on-line. A similar condition exists with most of the holdings in the developing nations. So, too, although the All Russian Collection of Microorganisms includes considerable mushroom microbiology and biotechnology resources, much information is not yet available in database formats.

In summary, the reports by MSDN have identified a substantial body of mushroom information, databases, and expertise already accessible worldwide through INTERNET and other specialized networks. These searches also suggest that the substantial number of parallel mushroom biotechnology capacities in the less developed countries are not linked to either INTERNET, or other accessible electronic networks - even in the cases where host institutions (e.g., botanical gardens, universities, national agricultural research centres) have e-mail addresses. Further, the searches indicate that potential LDC users of mushroom information available on-line (World Wide and other) will need specialized information services to identify and access the desired quality scientific resources.

**C. Discussions, Meetings, and Public Education Activities on MUSHNET** - A series of meetings on MUSHNET development were held during 1994-1995. These commenced with discussions with the representatives of the Centre for International Services in Mushroom Biotechnology (CISM Biotech) at the Department of Microbiology, Chinese University of Hong Kong (CUHK). The discussions focussed on steps necessary and progress in developing (1) the CISM node and databases structure, and (2) an on-line Asia network. During this visit to the Chinese University of Hong Kong (CUHK), the potential for the CISM Biotech to act as the Secretariat for MUSHNET was assessed. The Computer Centre of the CUHK was contacted for the level of services they could provide. The Computer Centre does not provide general database server facilities to the rest of the CUHK. Thus, for the CISM Biotech to provide

database services would entail acquisition of a much more powerful computer than CISM possessed. Also, special staff would have to be hired.

Staff of the CISM Biotech were trained in converting some of their paper data into appropriate machine readable databases. The extent of continuation of this effort is not known as the senior staff of CISM Biotech indicated extreme reluctance to make scientific information public due to concern over perceived intellectual property rights problems. It is our view that cooperation with the CISM Biotech on MUSHNET will have to wait until those intellectual property rights issues are clarified and resolved with respect to the CISM Biotech. No other potential nodes and other major sources of mushroom information have raised concern over the intellectual property rights of their respective information. Thus, for the immediate future MUSHNET is being built without participation of the CUHK - except in the area of technical training in mushroom growing technology which is the subject of a separate contract between the CUHK and UNIDO.

Planning meetings with representatives from the Mushroom Quality Control and Training Centres (QCTCs) in Thailand and the Philippines originally supported by the Carl Duisburg Gesellschaft (CDG). The discussions scientists in July 1995 focussed on the establishment of nodes in the two countries as part of a broader Asian mushroom biotechnology network and a global MUSHNET development effort. Both meetings were attended by the UNIDO BGE representative. The participation of the CDG is in doubt due to the transfer of its representative back to Germany. However, further communication with scientists in each of the countries indicate that participation by the QCTCs in MUSHNET is both possible and desirable. Much of the effort of the QCTCs is in end user training which must be an integral part of the MUSHNET goals.

A presentation on MUSHNET, as called for in the Terms of Reference, was made at the July 1995 *International Symposium on "Development of Small- and Medium Enterprises for Biotechnology Commercialization in Developing Countries"* held in Manila. The presentation by Dr. M. I. Krichevsky, **Information Technology Applications In Biotechnology**, was part of a workshop at the Symposium (See Appendix 3). The occasion of the Symposium also permitted a series of fruitful interactions on MUSHNET, with special emphasis on those from various Asian countries as well as South Africa. Follow-up activities with interested scientists are being undertaken.

Discussions were commenced in Washington with representatives of the International Union for the Conservation of Nature (IUCN). IUCN sustainable development programs in Pakistan offer a useful avenue for linking development of MUSHNET into that country. IUCN global activities, including in West Africa in particular, may offer added opportunities for strengthening MUSHNET development.

A meeting was held in Pune, India, in August 1995, with representatives of Bioinformatics, Distributed Information Centre, University of Poona and the Mushroom Project, MACS-Agharkar Research Institute in Pune. This exploration took place at the time of a biosafety course by the Information Resource on the Release of Organisms into the Environment (IRRO), an UNEP-sponsored scientific organization. The discussions led to an agreement to have the Centre - one of India's premier science informatics facilities - serve as one of the initial nodes in MUSHNET. The Centre's excellent computer capabilities (in both equipment and personnel) and their involvement in diverse India-wide, regional, and global biotechnology efforts makes this a particularly desirable node.

The Mushroom Project personnel have been involved in mushroom growing outreach projects for some years. They will provide specific subject matter expertise to the Pune Node. In fact, Dr. S. Kulkarni has provided databases suitable for incorporation into the MUSHNET information suite. (See Appendix 5 for one example.)

Among the follow-ups to the Manila Symposium is that with Dr. Ralph Kirby, from the Microbiology and Biochemistry Department of Rhodes University of South Africa. Dr. Kirby has agreed in principle to host a MUSHNET node.

As in the case of the University of Pune, South Africa's biotechnology community has a strong interest in advancing biosafety standards in the country and regionally, and to that end also cooperated with the MSDN and Bionomics International in convening a UN-sponsored IRRO biosafety course on the introduction of exotic organisms. The course (December 1995) involves African scientists from countries throughout the Southern African region. These activities

are the culmination of even earlier interaction with Bionomics International at the UNIDO IDDA-sponsored December 1993 *African Regional Symposium on Food Fermentation Technology* held in Dakar, on which Bionomics International prepared the consensus report for the Symposium and UNIDO. At that time the Rhodes University and Bionomics International representatives were requested by the Symposium participants to draw up a framework for a regional "African Mushroom Biotechnology Council" and an "African Mushroom Biotechnology Industry Initiative" within the context of a broader biotechnology networking effort for the Africa region as a whole.

Within this context, both correspondence and discussions have taken place in connection with future MUSHNET development in Africa. Discussions have taken place on establishing nodes in Kenya (Kenya Biodiversity Centre) and in Senegal (AFRICARE Dakar Office). Agreements in principle have been reached with both organizations to establish such nodes at their respective facilities. Extensive contact has also been advanced with representatives of the new Ministry of Science and Technology of South Africa, as well as the national Agricultural Research Council (which represents that country's agricultural research institutes). Discussions have focussed on mushroom biotechnology networking and development in both South Africa, and the Southern Africa region. Parallel correspondence and various discussions have also taken place in connection with the Ministers of Economic Coordination and Foreign Relations and the President of the Republic of Cape Verde. These focussed on networking by the Group of 5/Luso-African nations of which Cape Verde is a member, and the CSILS organization, chaired by the President of Cape Verde, which represents the governments of the Sahel Region). Likewise, a Bionomics International representative met in September 1995 with the Director of the Environment Program of the Organization of African Unity (OAU) to discuss MUSHNET. Realization of these potential activities will depend on the availability of future funds and resources.

**D. Identification and Selection of Initial MUSHNET Nodes** - The first two nodes are operational - Bionomics International and The Microbial Strain Data Network (MSDN). The five other nodes projected to actively join the MUSHNET in 1995 - in India, the Philippines, Thailand, Japan, and South Africa - will act as initial regional foci for MUSHNET activities.

Bionomics International provides design guidance for the initiation of the MUSHNET. As previously indicated in this report, Bionomics International provides the basic design and initial oversight of the establishment of MUSHNET. These activities proceeded in extensive consultation with Dr. Virginia Campbell, the UNIDO Backstopping Officer for this project. Meetings took place between Drs. Krichevsky and Campbell in New York City, Manila, and Bangkok. In addition, numerous briefings were accomplished by telephone, fax, and electronic mail. Thus, UNIDO was represented in detail in all phases of the MUSHNET development to date.

The Microbial Strain Data Network (MSDN) has developed an extensive database on sources of information available to the public in commercial and non-commercial computer databases related to mushroom cultivation. This database is being augmented with further exploration of the Internet. The MSDN currently is ascertaining which of its own node computers (at Sheffield University, UK; Tropical Data Base, Brazil; Chinese Academy of Sciences, China; RIKEN, Japan; World Conservation Monitoring Centre, UK; Bioinformatics DIC, India, etc.) are appropriate and willing to act as dissemination nodes for the MUSHNET. As noted above, the Indian node already is an agreed MUSHNET node as well. Recent conversation with the Director, World Data Center on Microorganisms (WDCM), RIKEN, Japan have confirmed the intent of the WDCM to participate in MUSHNET. Further, the RIKEN houses the Japanese Collection of Microorganisms, whose personnel likely will participate as well.

An international electronic mail discussion group will start on the MUSHNET in the last quarter of 1995. A number of nodes, as listed above, as well as the American Type Culture Collection, are potential hosts for the discussion group. However, a moderator must be chosen.

Other nodes projected to actively join the MUSHNET in 1995 are located in the Philippines, Thailand, India, Japan and South Africa. These five nodes will act as initial regional foci for MUSHNET activities.

The Indian node personnel have supplied databases as noted above. These will be publicly accessible by year's end.

The node in the Philippines will commence with a database on Philippine mushroom activities. The information is stored



as paper records. The records will be analyzed for format by Bionomics International for possible electronic scanning to avoid keying in the information.

Active discussions for participation are underway with organizations in Sri Lanka, Pakistan, Vietnam, Bangladesh, Russia, and China. Thus, by early 1996, the nodes of MUSHNET will be balanced between information providers and distributors. Some nodes will function in both ways.

The current node development thrust is in accord with the initial Asia organizing emphasis of MUSHNET. The organization and availability of an Asian network and of global information resource linkages is intended to significantly enhance other regional mushroom biotechnology initiatives.

**E. Other Contacts Initiated** - In November-December 1995 a Bionomics International intermediary is meeting with scientists from the University of Malaya, Kuala Lumpur, and other Malaysian institutions. Another Bionomics intermediary is meeting with representatives from various universities and other institutions in Colombo, Kandy, and elsewhere in Sri Lanka, during December 1995 and January 1996. Note is taken of the November 1995 meeting between a Bionomics International intermediary and scientists in Ulan Bator, Mongolia. Documentation on MUSHNET was transferred to the sole mushroom grower identified in country.

A meeting between the Chairman of Bionomics International and the Director of the World Data Centre on Microorganisms (WDC), Tokyo, Japan, had also been arranged for and took place in early December 1995 at the time of the international meeting in Washington, D.C. by the UNEP/UNESCO Microbial Research Centers Network (MIRCENET). As noted above, WDC agreed to serve as a MUSHNET node. The WDC, itself a MIRCEN, works closely with the World Federation of Culture Collections (WFCC) and the MSDN, and is a collaborator with the United Nations University on the development of, e.g., an Asian Nitrogen Fixation Network.

The above meetings parallel and supplement the letters of invitation (See Appendix 4) to scientists and others in LDCs to participate in MUSHNET. Further, interest in MUSHNET has been expressed by scientists involved in mushroom biotechnology in various developing nations, as well as institutions that are likely hosts for other nodes - e.g., the Biotechnology Information Centre (Moscow, Russia) of the International Scientific Committee on Biotechnology (COBIOTECH) of the International Council of Scientific Unions; the Institute of Biotechnology at the Universidad Nacional Autonomia de Mexico (at Guernavaca); and the Brazil Tropical Data Base at Campinas.

In addition to the organizations listed above, many other organizations and their respective interested technical and scientific officials and staff are linked to a diversity of local (national), regional, and other international networks. These and other interested and prospective organizations have significant information, technical, training, or other capacities relevant to and compatible with the attainment of the short- and long-term goals of the MUSHNET. We have had some contact with a number of other possible nodes in additional countries to those listed in this report. Pending availability of funds, these will be followed up in 1996 (see Section III).

### **III. SUMMARY AND POSSIBLE FUTURE ACTIVITIES: 1996**

Five basic goals are recommended to enhance MUSHNET during 1996-1997.

- 1. Extension and Refinement of Nodes System**
- 2. Expansion of Database Activities**
- 3. Continuation and Extension of Contacts and Public Education Activities**
- 4. Organization of MUSHNET**
- 5. Preparation of First Annual Report of MUSHNET**

**1. Extension and Refinement of Nodes System** - The development of the nodes system should proceed on four levels: (a) the strengthening of the Asian nodes system into a model for adaptation by other regions - e.g., Africa, Russia/Eastern Europe, and Latin America/Caribbean; (b) the development of true regional networks; (c) the

continued integration of science information resources and other nodes globally; and (d) further development and maintenance of the MUSHNET Bulletin Board. These activities will be significantly augmented and refined during 1996 by MUSHNET database development activities.

Assuming availability of funds, significant number of new Asian nodes are projected to actively join MUSHNET during 1996. These will be joined by facilities in Africa, the Russian Federation and Eastern Europe, and developing nations in the Western Hemisphere. While the development of an Asian mushroom biotechnology network will remain the emphasis during 1996, the initial nodes from the other regions will serve as foci for new regional activities beyond. Interactions on key nodes are underway with scientists from organizations in Russia and Latin America, as well as Africa. They also tend to be linked to local and regional networks which have participants with likely interest in MUSHNET. Thus, MUSHNET can proceed step-by-step with parallel regional efforts and local (national) outreach in Africa, Russia and Eastern Europe, and Latin America/Caribbean, towards evolving a fully distributed, global information resource and network.

**2. Expansion of Database Activities** - The extensive database activity by MSDN on sources of information available in computer databases related to mushroom cultivation, has identified new likely sources of information, as well as gaps. The database development activity should be continuously augmented by new database activities of network participants, especially contributing nodes. A significant amount of new database development efforts by LDC scientists, technologists, and entrepreneurs is being encouraged through MUSHNET. This will enhance their contributions to, uses for, and interactions with, network users. As these database activities proceed, there will also emerge a strengthened interest by LDC scientists and others in LDC science informatics improvements and standards. The MUSHNET system will afford both information and expertise (training, technical assistance, enterprise development, other) for more efficient response to LDC needs in those development areas.

MUSHNET is anticipated to greatly expand the global information resources available to those concerned with mushrooms from intellectual, esthetic, and commercial viewpoints. The extension of the system entails an ever-broadening and diversified network of experts from specialized areas within mushroom biotechnology. This will add and enhance access to other expertise - e.g., in spawn sources, fungicides, pesticides, regulatory development (safety and quality), toxicology, and genetics; various areas of SME development (growing, processing, etc.), as well as to experts and information in related scientific areas. MUSHNET should stimulate the production of new scientific databases of interest to industry. The combination of all of these activities will form a base to enhance sustainable development of small and medium size mushroom-based enterprises in LDCs.

**3. Continuation and Extension of Contacts and Public Education Activities** - The evolution of MUSHNET, as an Asian mushroom biotechnology network, and as a global information resource and network, entails persistent outreach and public education activity. Electronic forms of outreach and public education (e-mail and Bulletin Board activity) should be complemented by conventional forms of outreach (mail, meetings, presentations, and participation in scientific and other forums, etc.). These activities should continue to emphasize the further development of the nodes system. The outreach and public information activity should continue to be directed towards, on the one hand, LDC scientists, their country scientific institutions, and networks of LDC users and the ultimate target, entrepreneurial users of MUSHNET; and, on the other, counterpart and complementary interests in the industrialized countries. Both follow-ups to the 1995 contacts made (some of which are previously noted in this report), and new contacts made during 1996, should continue to lend themselves to a systematic identification, involvement, and organizing of nodes and other information resources, and of scientific and technical expertise - according to their respective specialized subject matter.

The establishment and expansion of the nodes-based system and the improvement and extension of the Bulletin Board should remain core activities. Stressed throughout MUSHNET's development should be the needs and demands of the various participants and users of MUSHNET (especially SME interests in LDCs, LDC networks of biotechnologists, and LDC food- and agriculture-related networks). This would be in accord with the goals of UNIDO and MUSHNET.

Increased attention will also need to be given to adequately informing decision-makers in the public sector and non-governmental international organizations (e.g., international scientific and environmental NGOs/PVOs, and agricultural, food technology, and nutrition research and development centers) about the diverse benefits of LDC mushroom biotechnology capacity-building and SME initiatives and of their relationship to MUSHNET. In this regard it may be appropriate for MUSHNET and UNIDO to consider preparing documentation of an educational nature regarding mushroom food technology, as well as mushroom biotechnology's relationships with other important areas of biotechnology capacity-building and SME development in non-food areas of development (fertilizer, animal feed, pharmaceutical, and other), including bioconversion technology development (biomass uses); as well as microbial diversity conservation and bioremediation; general fungal research and culture collection management; and food safety and biosafety. Likewise, the relationship of MUSHNET development to enhancing bioinformatics in particular, and science informatics generally, may afford useful added attention for MUSHNET in general, and mushroom biotechnology SME interests in LDCs in particular.

Particular initiatives should be explored with UNIDO/BGE for advancing MUSHNET-relevant biotechnology capacity-building activities in collaboration with (a) other United Nations and multilateral agencies and (b) international agricultural and environmental NGOs. These include, on the one hand, e.g., the Biodiversity Conservation and Biotechnology Program of the United Nations Environment Programme, the Global Environmental Facility (GEF), the Biotechnology Program of the World Bank, and regional banks such as the European Bank for Reconstruction and Development. On the other, they include NGOs such as the International Union for the Conservation of Nature (e.g., its Sustainable Development Program), the International Centre for Insect Physiology and Ecology, the International Centre for Research in Agro-Forestry, and the Intermediate Biotechnology Service.

**4. Organization of MUSHNET** - An exploration of alternative organizing frameworks for a MUSHNET effort has been initiated. Among the range of "networking" models that offer themselves for review are those of ANSAB, the MIRCENET (the association of the Microbial Research Centers), Naphthol's nitrogen-fixating networks, various agricultural research networks (Cassavanet, and other), as well as the MSDN. A service system for the communication of scientific and technical content among scientists and other users of that information necessarily goes beyond e-mail capacities. Critical to the determination of the mission and type of organizational structure of MUSHNET are the role and applications of bioinformatics services and other electronic information exchanges (Bulletin Board and other) on the subject matter.

Each of the above kinds of networking activities are in accord with and strive for establishing foundations for a sustainable network. However, the wide range of informational activity and the complexity of organizing the wealth of information, along with the users' needs for diverse aides to make use of and reason with available information, require a distributed network with a wide range of types of nodes.

Although a distributed informational network is intrinsic in much of the networking activity, some form of centralized administrative oversight will be necessary to coordinate systems design, standards, safety, quality control, training, and monitoring of node performance, systems usage, and adherence to scientific policy guidelines. Such administrative functions are best provided by a Permanent Secretariat. A Secretariat could be formed by diverse organizations responsible for different administrative functions of the network. That is, the Secretariat may itself be distributed among multiple organizations.

The distributed network option encompasses various advantages. It is compatible with and complements the efforts of diverse research, education, technical, and economic development organizations with an interest in mushroom biotechnology. It provides a global forum for information, technical, and other development needs in the subject matter areas. It encompasses diverse research capacities and backstopping for mushroom biotechnology development activities. It enhances the use of established scientific institutional resources and other organizations, both in LDC's, and beyond. It is user-driven and affirms a sense of collaboration and equal partnership among network members. It also allows for decentralized activities in the emerging producer countries and other country participants. It provides for a cost-effective alternative mechanism to the establishment of large-scale research programs.

Four organizing steps will need to be undertaken with MUSHNET and can proceed by the end of 1996: (i) formation of an initial Steering Committee; (ii) formalization of an organizational framework and By-laws; (iii) determination of the feasibility of "distributed" Secretariat; and, (iv) selection of the site(s) or host organization(s) for the MUSHNET Secretariat.

**5. Preparation of First Annual Report of MUSHNET** - It is anticipated that by the end of 1996 MUSHNET will have evolved to the point of being able to serve as a new, non-governmental organization. An important function of such an organization should be the preparation of an annual report for its members and the general public. A valuable public education role could be exercised by MUSHNET through an annual report on the state of networking and of mushroom biotechnology in less developed countries.

Careful consideration should be given to the report's possible diverse roles beyond management and organizational issues. MUSHNET reports could encompass observations pertinent to specific questions and problems facing mushroom microbiologists and biotechnologists, entrepreneurs, and national policy makers and others concerned with LDC biotechnology capacity-building and SME development interests. Issues addressed might include: food and biosafety standards; state of culture collections; microbial diversity conservation; LDC access to scientific data on mushroom microbiology and biotechnology; scientific standards for databases; toxicology; the status of LDC women in microbiology and biotechnology; biotechnology SME development techniques; etc. The presence and participation of scientists, diverse entrepreneurial development expertise, and other information users in MUSHNET allows it to formulate and discuss issues within interdisciplinary and biotechnology capacity-building frameworks.

## Appendix 1

The MUSHNET is conceived as a network of cooperating organizations with an interest in the biology, biotechnology, and commercialization of growing mushrooms for their intrinsic values in various areas. Thus the MUSHNET, while based in electronic communication, emphasizes the subject matter. Today's electronic communication technology provides sufficient support for message sending such that we now can concentrate on the content of the messages and leave the building of the message carriers to the specialists.

The subject matter within the immediate purview of the MUSHNET ranges from the biodiversity of mushrooms and related fungi, genetics, methods of cultivation, sources of cultures, processing, packaging, shipping, markets, marketing, regulations governing quality and safety, and quality control of all of the foregoing. Within biodiversity, issues of possible new edible fungi or introduction of varieties to new locales are included. In turn, such issues lead to consideration of non-food utilization of fungi (e.g., fine chemicals, pharmaceuticals, bioremediation, biotransformations). As monoculture of mushrooms and other fungi expands, whether or not genetic manipulation is applied, the risks associated with release of exotic species into the "local" environment and applicable regulations should be available through MUSHNET.

The wide range of information, the complexity of organizing the information for efficient use, and the necessity of aiding users so they can reason with the information, dictate a distributed network with nodes of varying functions. No single organization can provide the wide range of services such a network demands. Rather, cooperating organizations of diverse nature and function must link to form specialty nodes of the network.

However, a distributed informational network cannot function without some form of centralized administration for coordination of system design, standards, operations, quality control, fund raising and distribution, publicity, training, monitoring of node performance, system usage, adherence to policy guidelines, etc. These administrative functions are provided best by a permanent Secretariat which may, itself, be distributed among multiple organizations.

Other functions requiring specialized nodes included, but are not limited to: information gathering, programming, database building, dissemination, user help facilities, training, and publicity. Conceptually, the nodes acting as hosts for databases are easiest to describe. Such nodes provide automated user access to information. The node personnel are not required to be knowledgeable in, or even concerned with, the subject matter contained within the databases.

Where feasible, host nodes which are familiar with the subject matter may allow provision of "help desk" services to the users. Alternatively, the help desk node may stand alone and interact with a dissemination host node electronically.

The help desk provides a link between the end user and the broad range of information available. The personnel of the help desk must have generalist subject matter knowledge of the information relevant to mushrooms and related fungi as well as skills in using the computer and communication tools of the MUSHNET and the world-wide informatics systems, including Internet, Fidonet, and the various commercial systems (e.g., Dialog, Datastar). A further function of help desks is acting as an interface to MUSHNET for those users accessing information by ordinary mail, fax, telephone, etc.

The users of the information may or may not be the mushroom growers themselves. Often an interface level of personnel is required.

The rationale for help desks lies with the richness of the desirable information available but embedded in the vast, unorganized matrix of information unrelated to the specific question at hand.

The host and help desk nodes distribute information which already exists in a structured, machine readable form. The information may be distributed in printed form where electronic communication is not feasible or desired.

Largely, such distribution requires little interaction with the end user of the information after the search parameters for the desired information are set. This setting may well require a process of refinement usually limited in scope.

Another functional node category is training. Two broad categories of training are required. The first is informatics training in network use. Such training ranges from basic computer usage to using the world's information services. Training on use of services available through MUSHNET are of paramount importance.

The second category of training is practical how-to-do-it training, in a laboratory, other mushroom growing facility, or in a classroom setting. Various specialty courses are required for a full range of training services. These can encompass courses on study of the biology, diversity, and biotechnology of mushrooms and related fungi; pilot scale mushroom growing; small or medium scale commercial production; biosafety; legal regulations; entrepreneurial development, markets and marketing; etc.

Consideration of such topics as intellectual property rights and development of new products and processes can be included in various courses as demand dictates. All course designs include relevant bioinformatics training modules. Thus, informatics training is included in biological training. However, the converse may not be true, i.e., computer-based bioinformatics training courses can be very useful on their own merits.

All of the above node functions involve provision of information to end users. This requires the existence of the information in a readily distributable and accessible form. Much such information is available. However, there is an abundance of information cogent to the purposes of MUSHNET must be organized and in many cases transformed, for electronic distribution.

Nodes for such information organization and transformation must be identified and their contributions coordinated. For example, a microbial culture collection may have strains of mushrooms which have unique properties for biodegradation of unwanted materials. The characteristics of the various strains often will be kept in laboratory notebooks or, less often, in local computer files. The culture collection may wish to be a MUSHNET node or it may not. In either case, an information gathering node accepts the function of performing the tasks needed to make the information available to MUSHNET users.

Within this information acquisition function there are numerous areas of specialization. Culture collection information is but one. At the other end of the information spectrum lies business development, markets and marketing.

For the purpose of organizing this discussion, the categories of nodes are separated. Clearly, a single organization may wish to and be capable of acting in multiple node capacities.

## Appendix 2

### MUSHROOM INFORMATION PROJECT: PROGRESS REPORT FIRST STAGE IN IDENTIFYING RESOURCES COMPLETED

A survey of information resources on mushrooms has been carried out by the MSDN. The strategy has involved searching commercial database hosts and the Internet. Also, a simple questionnaire was circulated to over 50 organisations involved with mushroom cultivation or information provision.

The results of the survey have been recorded in simple PCFile databases. This has allowed the data to be recorded in a structured way and to be easily sorted and coded. A printout of the records is included in this Word Perfect file (Appendices A, B and C), supplied in full on computer disk. [Note: the printout alluded to here is not included in this report as it is approximately 80 pages long. The information is part of the MUSHNET databases that are being supplied.]

The original PCFile databases are included on the same computer disk. They can be output in a number of other ways, if required, including comma-delimited export files for import into another database system. There are two files. The main one is a list of databases and listservers, with contact details for the data providers. There is a second file which lists organisations, mainly online hosts, which provide access to one or more of the information resources cited.

#### 1. Commercial database hosts:

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The following hosts were searched directly to characterise the information sources on mushrooms: DataStar, STN, Orbit, GreenNet.

The largest European host is DataStar (over 200 databases, very strong in science, technology and commerce) and this provided the bulk of the entries. This was supplemented with additional information, particularly patents, available on the other hosts.

Documentary sources from service providers, and other reference works such as the Directory of Online Databases, were used to describe databases on the following hosts: Dialog, DIMDI, BRS, ESA-IRS.

#### 2. Internet resources

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Internet-gophers and list servers with relevant information were identified. Starting with the gopher at the Clinical Research Centre in Harrow, selections of other gophers were made based on the title of the information provider. Molecular sequence databanks were among the databases searched. A number of e-mail addresses of relevant BIOSCI/USENET bulletin boards were collected.

Gophers essentially allow users to move from one database to another, on any host computer, and enter search terms through a standard user interface. List servers provide the subscriber with postings of all contributions made to a given bulletin board/online discussion. In many cases the full contact details are not available, as the only information needed to subscribe is an e-mail address.

#### 3. MSDN network

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Appropriate culture collection databases on the MSDN network were searched.

#### 4. Survey of culture collections and specialist services

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Over fifty culture collections and specialist services in the field of mycology were identified, largely through the World Directory of Collections of Cultures of Microorganisms (online at World Data Centre, Japan). A questionnaire was sent out by fax and by mail. The questionnaire itself was described in an earlier report. Twenty responses have so far been

received which represents a very high return, over 30%. The questionnaire was aimed at eliciting details of information resources held at these organisations, rather than details about the organisations themselves. The responses are included with the file of database entries. Comments include remarks about whether the information is publicly available or not.

#### 4. Database files in WP4 format

NOTES: Explanation of fields in the 'DBASES' file:

DATABASE: Name of database.

NAME: Personal contact name.

ORG1, ORG2: Name of the data provider.

ADD1-ADD3, COUNTRY: Address of data provider.

TEL, FAX, EMAIL: For data provider.

KEYWORDS: The first word has been used to give a single, overall classification of the database, and this term is followed by a forward-slash (/). The databases have been put into one of the following categories: SCI-TECH, COMMERCIAL, PATENTS, NEWS, LEGAL, TRADE-ASSOCIATION. The terms following this are free-text descriptions of the content of the database, particularly with respect to the present application, information on mushrooms.

COVERAGE: Lists the kinds of source materials the data-provider uses to obtain information.

HOSTS: Host services which distribute the database bulletin board (not necessarily comprehensive).

START: The year the database started. This might differ for various host systems, in those cases where the database is loaded on more than one. If so, the earliest date has been listed.

UPDATE: Date this record was updated (YYMMDD).

FREQUENCY: How often the database is updated.

MEDIA: Means of distribution of the data.

SIZE: Where known, the approximate size (number of records) of the database is given as a power of ten (ie. SIZE=4 means that the database has over 10,000 records, but less than 100,000).

HOLDING: Where known the approximate number of records holding information on mushrooms is given to a power of ten, as above. However, where the number of records is in single figures, a value of 1 is still assigned here, to avoid implying zero records, so HOLDING: 1 means there are between 1 and 99 records on mushrooms

TYPE: indicates whether the resource is a database (db), bulletin board (bb) or culture collection (cc). It is further categorised by /c if it is available through a commercial host system, or /i if it is available through the Internet. MSDN databases are categorised /i because the database providers make no charge for accessing their information, the only charge is the MSDN subscription fee.

STATUS: in those records without full contact details (list B) this contains the descriptor "incomp". The resource can usually be accessed through a gopher or by subscribing to a list server.



## 5. Analysis

A preliminary characterisation of the databases identified so far shows the following.

PRINCIPLE TYPE OF INFORMATION IN THE DATABASES B-BOARDS	NUMBER
Scientific/Technical	108
Commercial	46
Patents	4
News	4
Legal	3
Trade-association	1
<b>TOTAL RESOURCES</b>	<b>164</b>

NOTE: Only one category of information was chosen to classify the database; there is no overlap in the above.

TYPE OF RESOURCE	NUMBER
Databases ( of which Culture collections 20 )	148
Bulletin boards	15

COMMERCIAL HOST/INTERNET ACCESS	NUMBER
Commercial	116
Internet	32

The next phase of this effort was to extend the research of resources on the Internet. The following techniques were used. Searches were carried out on World Wide Web, starting with publicly available query sites, a list of URLs (addresses of Web pages) were obtained. A connection was made to each site to evaluate the information and to obtain further links to related sources. Around 20 separate Web sites with significant mushroom information were identified, and several more gopher sites.

The geographical distribution was concentrated in North America and Europe (including Russia), but other regions were also represented. The sources were characterised as: bulletins, scientific databases, societies, and directories of people and institutions. Information included graphics (images of mushrooms) as well as text. The second technique was to query the local Archie server, which supplied over 20 FTP sites.

These sites were sampled by downloading files which appeared to have scientific relevance. The information varied greatly in age, and in detail. Again the files were found to contain bulletin text, databases and graphics. This second method is time-consuming and unrewarding - the contents of the files are not described in full, their names give the only clue, and the whole file has to be downloaded to view. This can be slow. Much of the material consists of cooking recipes, which were ignored for this exercise.

The scope of information on the Internet has thus been assessed. In the next phase this work will be systematically extended to build a directory of Internet resources with description of file contents and how to access them.

## Attachment 3

# INFORMATION TECHNOLOGY APPLICATIONS IN BIOTECHNOLOGY

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**FACTORS IN DEVELOPMENT OF A COMMERCIAL ENTERPRISE:** Developing or enhancing a commercial enterprise involves consideration of many factors to achieve sustainable success. Consider the following quite incomplete illustration of the complexity of the factors.

**WHAT CAN BE SOLD?** The usual major categories of commercial activity are the sale of services or products. The products may be gathered and sold with little or no further processing or manufactured. For the purposes of this discussion, we shall consider provision of services for supporting the sale of products. Later we shall concentrate on a specific example of biotechnological manufacturing, the cultivation of mushrooms as a commercial enterprise. We shall make the argument that successful commercialization of mushroom cultivation must be supported by a solid base of available information. This is true of such cultivation from small to large scale.

**Services:** Services in support of manufacturing products include:

- Information
- Teaching
- Personnel supplementation
- Transportation
- Tourism
- Lodging
- Sales

We list tourism and lodging because many industrial concerns or the surrounding communities make supplementary income from conducting tours of facilities. Some biotechnology-based concerns provide examples which come to mind: chocolate candy factories (e.g., Hershey in the U.S.A. and Cadbury in the U.K.), tours to view tulips in bloom in the Netherlands, the Busch Gardens amusement parks associated with the Busch breweries in the U.S.A., and the tours of the world's largest concentration of mushroom growing facilities at Kennett Square, PA, U.S.A.

**Products:** Gathering materials from the environment is the simplest form of developing products for sale. Mineral prospecting, while out of the scope of this discussion, is a good example. Since the subject of the Symposium is biotechnology, illustrative activities include wood products with the attendant rampant deforestation in both the developed and developing nations. Unfortunately, gathering of wood products only rarely proceeds in a sustainable manner.

Food and fiber gathering includes such diverse activities as gathering wild fruit and berries, edible fungi (a lucrative enterprise in many places such as truffles in Europe, morels in North America, Europe, and Asia, etc.), grasses, and land and water animals (also often over gathered). Many specific examples within, and in addition to, the foregoing list exist. Here too, we shall not consider enterprises based on gathering as such activity is outside the area of biotechnology.

**Manufactured materials:** The guide book I consulted in preparation for this, my first trip to the Philippines, listed handicrafts of the Philippines attractive for purchase as: polished minerals, jewelry, woodcarving, clothing, and woven baskets. These categories, while artisanal manufacturing, are not enterprises based on biotechnology. Therefore, they shall be considered outside of the schedule of the Symposium.

**Cultivated materials:** Enterprises based on biotechnology, by definition, must involve purposeful cultivation of biological materials. Cultivation-based enterprises attract entrepreneurial interest in developing nations for many reasons. One that is very important is the low capital investment compared to many other forms of manufacture. A rice field is cheaper to establish than a steel mill. Also, the raw materials are simpler to obtain.

The biological categories of cultivatable organisms commonly are broken down into animals, plants, and microorganisms (including viruses). In all cases, the cultivation activity requires a solid technical base for successful commercialization. Sometimes the technical problems are simple to solve.

In many enterprises, the knowledgeable application of pasteurization techniques can mean the success or failure of the enterprise. The classic and original case is Pasteur's efforts for the wine industry of France. Dairy products are the most wide spread use of pasteurization and involved much technology development. A ginger products company in Australia survived by the introduction, by the late Prof. V.D.B. Suman, University of Queensland, of pasteurization into their processes. Proper pasteurization of compost is basic to the processes of much commercial mushroom growing.

Many questions must be answered before choosing an enterprise if it is to be successful. In some cases, the decisions are obvious and forced by circumstances. We are unlikely to even consider large scale fresh water fish farming in places where water is in short supply. A few of these questions follow.

Does the place that is available to us have adequate land and/or water. If cultivation requires containment, do the facilities for adequate natural or artificial exist?

Are there adequate source of required cultivable materials. Are they wild types, produced by selective breeding, genetic manipulation? Do they breed true or must the source material be continually refreshed?

What kind of products will result from the cultivation?

- food
- fiber
- fertilizer
- fine chemicals & drugs
- enzymes
- biologics (antigens, antibodies, etc.)
- cells for biotransformation
- cells for bioremediation
- cells for biological control

**Production science and technology:** Having chosen a product for commercial exploitation, more questions arise on the ability to successfully produce a marketable product.

Is the product and its production based on sound scientific knowledge of the basic phenomenon?

Is the technology necessary for success known and available?

Is the product safe for the consumer? For the producer?

Do the production, packaging, and marketing conform to applicable laws and regulations for domestic use? For export?

The foregoing questions deal with the facilities and capacities necessary to carry out the process. The next consideration is that of the economic viability of the enterprise.

**IS THERE A MARKET FOR THE PRODUCT?** Considerations for assessing the marketability and cost effectiveness of the biotechnology enterprise can be exemplified by the following summary outline.

- I. Where to sell?
  - A. Local
  - B. Regional
  - C. International
- II. Economics of selling
  - A. Capitalization required
  - B. Cost of production and packaging
  - C. Cost of shipment
  - D. Cost of marketing
  - E. Selling price
  - F. Profit or loss?
- III. Feasibility of economically sound production
  - A. Local conditions
    1. Appropriate climate
    2. Facilities
    3. Community social structure
    4. Location
    5. Near markets
    6. Transport to market
    7. Available labor pool with appropriate skills
    8. Marketing infrastructure
      - a. self-marketing by producer
      - b. cooperative
      - c. supplier to centralized marketing enterprise
      - d. Marketing knowledge

**BIOTECHNOLOGICAL ENTERPRISES: THE MUSHROOM PARADIGM:** Mushroom cultivation for commercial exploitation continues to increase rapidly. The world production of edible mushrooms doubled in the period 1986-1991, from 2,176,000 to 4,273,000 metric tons fresh weight as reported by Chang (in Chang, S.T., Buswell, J.A. and Chiu, S.: *Mushroom Biology and Mushroom Products*, The Chinese University Press, Shatin, N.T., Hong Kong).

**Why mushrooms?** Now we shall consider mushroom cultivation as a paradigm for much of biotechnology and the supporting information needs in the developing world. There are many reasons for the phenomenon of the rapid increase in mushroom monoculture, especially in developing nations.

A solid base of scientific, technical, and commercial factors exist to support successful commercial cultivation of mushrooms. This body of information accumulated during the long history of culture of these fungi. Some of these factors are outlined as follows.

- I. Small to large scale cultivation possible
  - A. Successful enterprise at village level
  - B. Scale up effective
- II. Low capital costs
- III. Good profit margin
- IV. Realistic technology requirements
- V. Ready and sustainable markets
- VI. Ready acceptance in many markets
- VII. Important as food
  - A. Good protein source
  - B. Palatability high in many cultures

- C. Can be stored for short times
  - D. Can be stored dry, low spoilage
  - E. Can be stored in metal or glass containers
- VIII. Many non-food uses
- A. Pharmaceuticals and other fine chemicals
  - B. Bioremediation
  - C. Biotransformation
- IX. Readily transported to market

**Information requirements:** S.T. Chang (in the proceedings of the First International Conference on Mushroom Biology and Mushroom Products, The Chinese University Press, Shatin, N.T., Hong Kong) presents a modified Venn diagram in the shape of a mushroom. The stem is Mushroom Biology. Mushroom Science is shown as the combination of Composting and Environmental Engineering. Mushroom Biotechnology is the resultant of Fermentation Technology and Processing. The top of the mushroom cap consists of Marketing and Management. These broad categories comprise the framework for the content available in through the information delivery system that will now be described.

**MUSHNET background:** International interest in substantively increasing promotion of mushroom biotechnology arose from four concurrent activities: (1) a pioneering five-year project (1990 - 1995) for Small-Scale Biotechnology Industries Development in Thailand and The Philippines led by the Carl Duisburg Gesellschaft; (2) UNIDO biotechnology initiatives in 1991 and 1992 exploring the potential of mushroom development in less developed countries; (3) the formation in March 1992 of the Asian Network-for Small Scale Agricultural Biotechnologies (ANSAB); and (4) the 1992 efforts led by Professor S.T. Chang of the Chinese University of Hong Kong to found an International Mushroom Centre. These activities emphasized technology transfer, largely through training by various mechanisms.

Much of the biotechnology information required to establish a traditional cultivation enterprise was, and in many cases still is, traditionally transferred as folklore, social practice, apprenticeship, and even religious practice. As the population of the world grows, the tension between space use and conservation requires we find more effective ways of utilizing these resources. Further, the need to provide increasing populations with the results of the biotechnology at the lowest possible capitalization costs requires that we cannot afford the wasteful practices of the past. The need for efficiency and low start up costs is greatest in the developing nations. Unfortunately, access to the scientific and technical knowledge is least where the need is greatest.

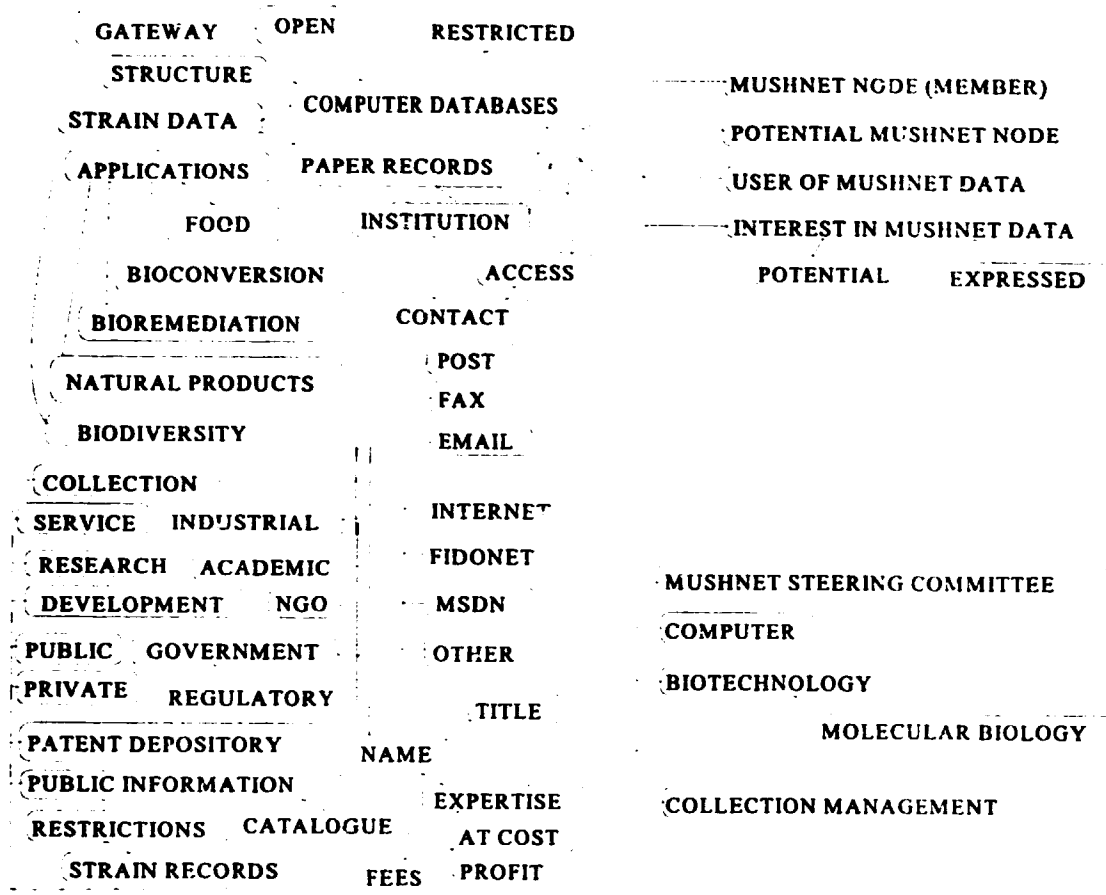
The MUSHNET initiative, i.e., the establishment of an informational network to support mushroom biotechnology and commercialization in developing nations, originated in the UNIDO's December 1991 Industrial Development Decade for Development of Africa (IDDA) "Expert Group Meeting on the Applications of Biotechnology to Food Processing in Africa" held at the International Institute for Tropical Agriculture (IITA) in Ibadan, Nigeria and in the request to UNIDO by the Chinese University of Hong Kong. The first focus of MUSHNET in Asia.

The MUSHNET is conceived as a network of cooperating organizations with an interest in the biology, biotechnology, and commercialization of growing mushrooms for their intrinsic values in various areas. Thus the MUSHNET, while based in electronic communication, emphasizes the subject matter. Today's electronic communication technology provides sufficient support for message sending such that we now can concentrate on the content of the messages and leave the building of the message carriers to the specialists.

The subject matter within the immediate purview of the MUSHNET ranges from the biodiversity of mushrooms and related fungi, genetics, methods of cultivation, sources of cultures, processing, packaging, shipping, markets, marketing, regulations governing quality and safety, and quality control of all of the foregoing. Within biodiversity, issues of possible new edible fungi or introduction of varieties to new locales are included. In turn, such issues lead to consideration of non-food utilization of fungi (e.g., fine chemicals, pharmaceuticals, bioremediation, biotransformations). As monoculture of mushrooms and other fungi expands, whether or not genetic manipulation is applied, the risks associated with release of exotic species into the "local" environment and applicable regulations should be available through MUSHNET. A partial view of the informational interrelationships and richness of the universe of useful information related to mushroom monoculture is given in Figure 1.

The wide range of information, the complexity of organizing the information for efficient use, and the necessity of aiding users so they can reason with the information, dictate a distributed network with nodes of varying functions. No single organization can provide the wide range of services such a network demands. Rather, cooperating organizations of diverse nature and function must link to form specialty nodes of the network.

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

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The users of the information may or may not be the mushroom growers themselves. Often an interface level of personnel is required. The persons wishing to establish a new enterprise such as growing mushrooms at the village level may not have either the skills or the motivation to contact a help desk themselves. Rather, one or more persons, versed in the local language, culture, and detailed social structure will act as these intermediates. The intermediates will act as bidirectional conduits to introduce the technology to the local potential producers and act as users of the information systems available as questions arise. Many developing nations have such outreach infrastructures. The infrastructures may be official or unofficial and are of varying degrees of sophistication.

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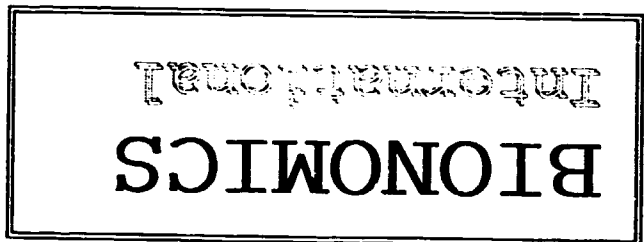


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**Final note:** The success of any information transfer system depends entirely on the ability of the system to deliver the information exactly where it is needed and in a form that can be utilized by those requiring the information. For example, the preponderance of the world's scientific and technical information in computers is in English. Most developing nations do not use English as their first language. In fact, at the level of the person performing the act of cultivation, any knowledge of English is rare in the countries with first languages other than English.

Language can be a simple barrier to information transfer. More subtle, and even more difficult, are local mores which must be understood. The above network design overview assumes that a locally viable mechanism exists for outreach to the persons actually doing the cultivation, processing, and marketing. The help desk rarely will be accessible to the village. In the teaching sense, the network trains the trainers. On a practical level, final delivery of the information remains a local responsibility.



Dear Colleagues,

Through this letter, we wish to explore the extent of possible interest in mushroom biotechnology, development in Malaysia as well as Malaysian participation in a global mushroom biotechnology networking initiative (MISHNET), sponsored by the Biotechnology and Genetic Engineering (BGE) program of the United Nations Industrial Development Organization (UNIDO). Today's computer and communication technologies offer new powerful tools to scientists and small and medium size business developers in all areas of the world, to secure access to and exchange scientific and commercial information vital to growth. A key method for promoting such aims is electronic and traditional networking.

Thus, we invite and encourage you to join this UNIDO-sponsored collaborative effort, building and sharing the benefits of a distributed international network complementing biotechnology, industry development. We would be delighted to work with scientists and others in Kuala Lumpur and elsewhere in your country, to advance and augment through electronic collaborations, new partnerships in biotechnology development.

We wish to explore the feasibility of establishing, in your country, a MISHNET communications "node" to enhance local mushroom-related research and development pursuits. The attached brief description of the MISHNET summarizes the design of MISHNET. It is a network of cooperating organizations acting as network nodes with an interest in the biology, biotechnology, and commercialization of mushrooms. Thus, MISHNET emphasizes a subject matter whose scope includes the biodiversity of mushrooms and related fungi, genetics, methods of cultivation, sources of cultures, spawn resources, substrates, fungicides and pesticides, as well as processing, packaging, shipping, markets, marketing, standards governing quality and safety, and quality control in general.

MISHNET originated in, respectively, the 1991 Expert Group Meeting on the Application of Biotechnology to Food Processing at the International Institute of Tropical Agriculture (IITA), Nigeria; and under the auspices of UNIDO and the United Nations Industrial Development Decade for Africa (DDA), and in a request to UNIDO by the Chinese University of Hong Kong. The basic design of the MISHNET is now complete. The venues for the first nodes in India, Philippines, and the Sheffield, England-based Microbial Strain Data Network (MSDND) have been agreed upon. Initial databases are constructed by MSDND and the Indian node in Pune. Other nodes projected to actively join MISHNET by the end of 1995 are in Thailand and South Africa. These nodes will serve as the foci for initial regional activities. Discussions on further nodes are underway with scientists from organizations in Pakistan, Sri Lanka, Bangladesh, China, and Japan, as well as Russia. Thus, while the initial focus is on Asia, MISHNET is designed to help facilitate parallel efforts in Africa, Russia, and elsewhere.

The MSDND, an international scientific non-governmental organization founded in 1981 by the Scientific Committee on Biotechnology (COBIO-ECH) and Committee on Data in Science and Technology (CODATA) of the International Council of Scientific Unions (ICSU), the World Federation of Culture Collections (WCCC), and the International Union of Microbiological Societies (IUMS) has developed an extensive database on sources of information available in computer databases related to mushroom cultivation. This database is continually being augmented by MSDND. An international electronic mail (e-mail) MISHNET discussion group is also evolving. During 1996 the MISHNET nodes will reflect a balance of information providers and local and other distributors of information. Some nodes will function in both ways. Providing design guidance for the initiation of MISHNET in Biometrics International, which, like MSDND, is a not-for-profit, non-governmental scientific organization.

The Indian node has contributed databases including the basic biology of basidiomycetes (taxonomy, spore descriptions, etc.), lists of toxic mushrooms of India, and the commercial production of mushrooms in India *vis a vis* the rest of the world.

A node operated by your country's scientific community would link it world-wide to other members in the MUSHNET for useful exchange purposes. Further, it would increase your access to other valuable scientific and technical information resources and technical expertise. Last, though not least, it can be a productive instrument enhancing bioinformatics development and reinforcing scientific networking in your country and region.

If you are interested in participating in MUSHNET, we encourage you to identify and communicate to us:

- the kind of node services (that is, the type of node, e.g., information/database provider, informatics training, mushroom biotechnology training, technical assistance provider, information distributor, or other) which you and your colleagues are able to contribute to MUSHNET;
- the name of and other necessary details on the host organization for the type of node you have identified as your focus; and
- the names of principal microbiologists and/or other scientists, technologists, etc., and of the principal contact or liaison for our future interaction.

Please share with us your views regarding participation in MUSHNET, the state and needs of mushroom biotechnology, bioinformatics, microbial databases, electronic networking, microbial culture collections, and other areas of shared scientific interest.

I am pleased to enclose a copy of "Information Technology Applications in Biotechnology", a recent presentation at an international conference on Small-and Medium-sized Biotechnology Enterprise Development held in Manila.

We look forward to your active collaboration with MUSHNET.

Sincerely yours,

Micah I. Krichevsky, Ph.D.