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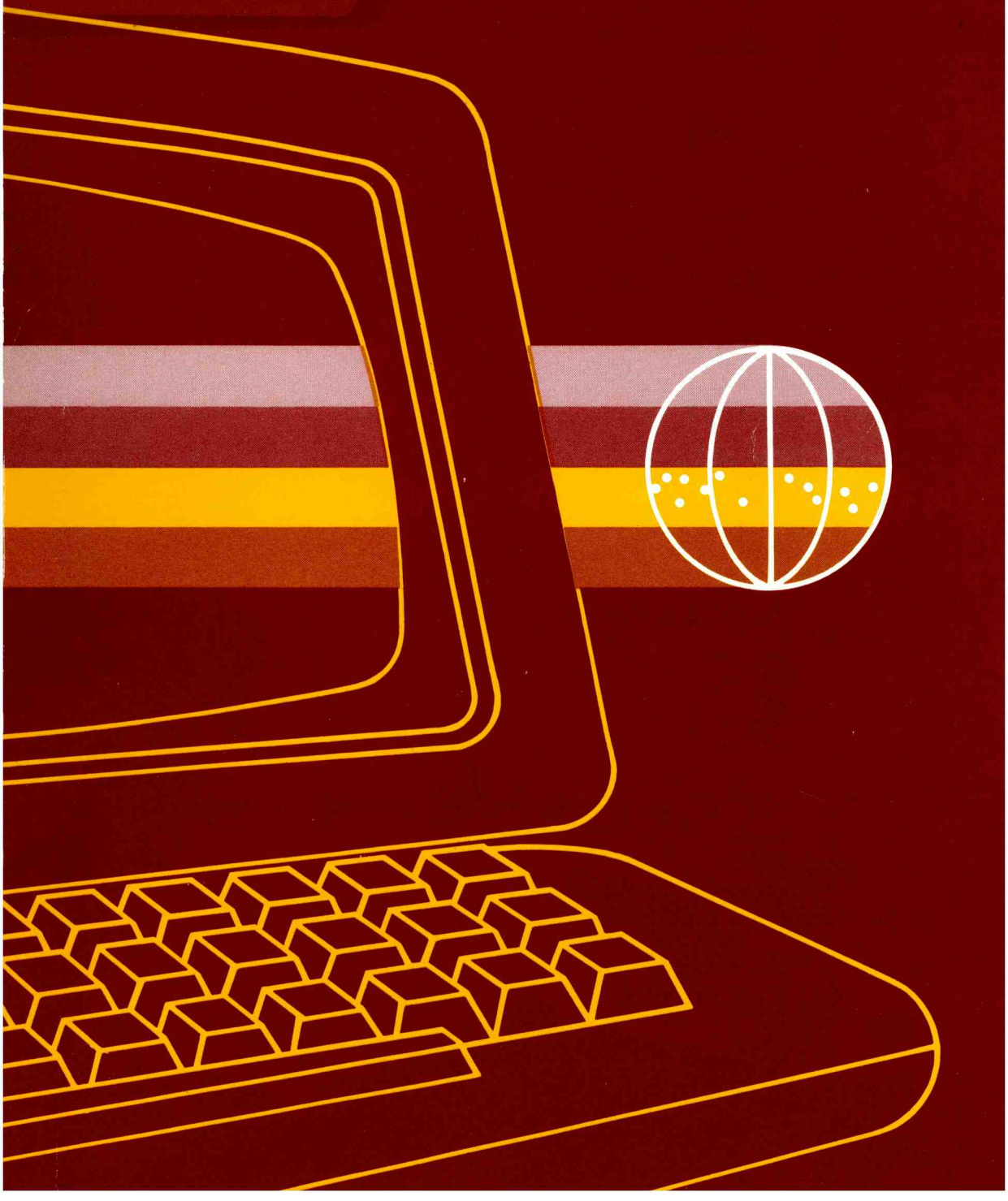

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International Computer-Based Conference on Biotechnology

A Case Study

Editor: D.A. Balson

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Abstract

An international computer conference on the bioconversion of lignocellulosics for fuel, fodder, and food took place from May to December 1983. It was initiated to evaluate the appropriateness of using computer conferencing to facilitate scientific discussions and to explore the application of the subject matter to development purposes. Individuals intimately involved in the organization and evaluation of this activity contributed chapters documenting the background, organization, operation, evaluation, and results. These chapters reflect the personal views of the authors, allowing the reader to view the activity from a number of different perspectives.

Generally, the technique of computer conferencing was accepted by this user group as a viable medium for facilitating scientific research. Although the industrialized-country researchers did not find the content of the discussions very valuable, the developing-country researchers found it extremely pertinent and appropriate. The most important outcome of this activity, however, was its contribution to the body of knowledge concerning the use of this technique in the facilitation of cooperative research activities.

Résumé

De mai à décembre 1983 s'est tenue une téléconférence informatisée internationale sur la bioconversion de matières lignocellulolytiques en combustible, fourrage et nourriture. Elle avait pour objet de déterminer le bien-fondé de l'utilisation de la téléconférence pour faciliter les discussions entre scientifiques et d'étudier l'utilisation de ce mécanisme à des fins de développement. Les personnes chargées de l'organisation et de l'évaluation de cette activité ont rédigé des documents sur l'origine, l'organisation, le fonctionnement, l'évaluation et les résultats de la téléconférence. Chaque document reflète les idées et opinions de son auteur, ce qui permet au lecteur de regarder cette activité à partir de différents points de vue.

Les participants ont reconnu, de façon générale, l'utilité de la téléconférence informatisée pour la recherche scientifique. Bien que les chercheurs des pays industrialisés aient jugé peu intéressants les sujets traités, les chercheurs des pays en développement, pour leur part, les ont trouvés très pertinents. Cette activité aura eu pour principal mérite de contribuer à l'approfondissement des connaissances sur l'utilité des téléconférences dans la promotion des activités de recherche en collaboration.

Resumen

De mayo a diciembre de 1983 se celebró una conferencia internacional computarizada destinada a analizar temas relativos a la bioconversión de lignocelulosa en combustible, pienso y alimentos para el ser humano. La conferencia evaluó la conveniencia de la utilización de las conferencias computarizadas para facilitar las discusiones científicas y para explorar la aplicación de los temas discutidos a los esfuerzos de desarrollo. Los expertos que participaron en la organización y evaluación de esta actividad contribueryon capítulos sobre antecedentes, organización, operación, evaluación y resultados. Los mismos reflejan las opiniones personales de los autores y ofrecen diferentes puntos de vista sobre estas actividades.

En términos generales, este grupo de usuarios opinó que la técnica de conferencias computarizadas resulta un medio viable para facilitar la investigación científica. Los investigadores de los paises industrializados no consideraron muy valioso el contenido de estas discusiones; sin embargo, los investigadores de los paises en vias de desarrollo estimaron que los temas tratados fueron pertinentes y apropiados. Esta actividad contribuyó sobre todo a aumentar el caudal de conocimientos relativos al empleo de esta técnica para facilitar la colaboración en las actividades de investigación.

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Moderator's Viewpoint

Murray Moo-Young[1]

It was with some reservation that I accepted the invitation to serve as the overall moderator of this conference. On the positive side, the subject matter (preselected by C.G. Hedén, Stockholm) was of direct interest to my own research work and I was assured that I would receive assistance from a rapporteur and various session co-moderators; in addition, I was told that the conference would be primarily addressed to developing-country concerns for which I have deep empathy. On the negative side, it was not clear how the computer-based system would work because virtually all of the proposed participants had no previous experience with it; and, furthermore, I was skeptical as to the willingness of participants to share their research results without encouragement via the usual visual or aural contact. In the end, the challenge to experiment with a new electronic medium for communicating with research colleagues on topics of common interest was too attractive to refuse.

In this report, a personal view of the conference experiment is given. An outline of the program format and topics is followed by a presentation of the results and some recommendations. Separate reports, given elsewhere, give statistical analyses of questionnaire responses from participants. In particular, those reports deal with content analysis and participants' experiences. By contrast, this report addresses the perception and experience of the moderator.

The information is based on a limited group of participants. The overall profile of this group is as follows: Number of individual and group user id's = 172. Number of registered countries = 23, which included countries in North America, Europe, Africa, Australasia, and the Orient, but excluding several others (USSR, FRG, DDR, etc.), which participated via European "nodes" during a 1-week "dispersed workshop" phase toward the end of the conference. The number of developing countries that participated mostly off-line via telexes = 14.

Background to Conference

In recent years, there has been an increasing interest in electronic means of networking groups and individuals for technical information exchange or data base development. A computer-aided conferencing system offers several advantages over the more conventional conferences that require the actual meeting of participants or synchronous audio/visual communications. The net result is a reduction in travel costs and the possibility of ongoing interactions with various parts of the world, allowing convenient local hours for all participants. EIES

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(Electronic Information Exchange System), operating out of a host computer in the New Jersey Institute of Technology, USA, was the system chosen because its features were considered to be user-friendly, especially for neophytes (1). Our European colleagues interfaced via the COM system and developing countries, for the most part, participated off-line via telexes and letters.

The conference addressed existing and potential uses of bioconversion processes for the production of fuels and animal or human foodstuffs from lignocellulosic materials. Various aspects of these processes (scientific, engineering, economic, social, etc.) were suggested for coverage. Discussion of and development of a data base of information on an area of biotechnology that is of current global interest and of particular relevance to problems in Third World countries were to be promoted. Unlike a conventional conference, there was no formal presentation of papers. In fact, it was intended to be more like the discussion, or "question and answer" period following the presentation of papers, interspersed with brief commentaries provided by the program moderator and co-moderators. As a basis for discussion, I prepared the following background material, which was supplied in advance to all participants. In my capacity as the overall conference moderator, I was allowed co-moderators for each of the five sessions discussed in the following sections. In addition, I personally conscripted one of my research assistants, Arlene Lamptey, to manage the numerous computer connections throughout the conference period. Without her help, my participation in the experiment would not have been possible.

Overview of Program Topics

Global depletion, especially in Third World countries, of fuel, fodder, and food commodities has led to current considerations of lignocellulosic bioconversion processes for producing these products. Lignocellulosic materials comprise the world's most abundant renewable resource having favourable distribution in many industrially poor countries that are generally blessed with the requisite photosynthetic power for their generation. The high carbohydrate content of lignocellulosics (up to 50% cellulose and 40% hemicelluloses) is attractive for bioconversion process strategies; compared to corresponding chemical routes, higher product yields and lower processing energy requirements are theoretically possible. Counteracting these encouraging scientific observations are some real-world techno-economic problems that remain to be resolved, e.g., the inherent slowness of bioconversion rates, especially with these recalcitrant materials, and the difficult materials handling of a noncentralized, low-density, bulk feedstock supply of basically forestry material (wood) and agricultural crop residues (straws, stovers, etc.).

Several literature reviews on this subject matter are available. Particular attention is drawn to a recent monograph (2) that includes an appendix on activities in developing countries. It was hoped that this reference, and the cross-references generated by it, would serve as a basis for initiating and maintaining most of the conference discussions. Some basic questions to be addressed included: What is the most attractive lignocellulosic material for a given process? What is the most efficient process for a given feedstock? What are the quality characteristics of the products and byproducts? What are the relevant analytical methods and instru-

mentations available? What are the socioeconomic possibilities of operating a given process on a small scale or in Third World countries with unsophisticated technology skills? What are the immediate, near-term, or long-term prospects for a given process? Where or from whom can more information on a particular topic be obtained? Classifications and highlights of the five areas to be discussed follow. By including a subtopic entitled "miscellaneous" in each of the five sessions, of which "general considerations" is one, discussion of virtually any aspect of the subject matter was possible.

(a) Upstream Process Considerations (Session Co-Moderator: J.N. Saddler, Ottawa)

In general, scientific researchers at the bench scale level often forget the importance of upstream or downstream processing costs or both. In the case of lignocellulosic bioconversion processes, these costs become prohibitive for most, if not all, of the newly proposed processes. Thus, there is a strong incentive to improve existing lignocellulosic pretreatment methods or to develop new, more efficient ones.

Chemical methods involving acids (mainly H_2SO_4), alkalis (mainly NaOH), and organic solvents (various candidates) suffer from low yields, primarily because of degradation products formation. Biological (mainly fungal) and enzymatic (mainly *Trichoderma viride* extracts) methods are too slow without chemical or physicochemical pretreatment. Most methods must be preceded by physical techniques (mainly crushing and grinding) to enable suitable mass or heat transfer rates of pretreatment fluids. Various effects are promoted by these methods (hydrolysis, delignification, depolymerization, decrystallization, comminution, swelling, etc.) to allow solid substrate accessibility or the formation of liquid substrates (glucose, xylose, etc.) or both. The search for effective catalysts (mainly inorganic) to enhance hydrolysis rates is intense. To minimize or avoid the necessity of pretreatment, the use of industrial waste residues (e.g., papermill pulp sludge, coffee grounds, sugarcane bagasse) is to be encouraged; in some cases, an extra credit for their utilization may be gained because of the concurrent environmental pollution abatement (biological oxygen demand (BOD), chemical oxygen demand (COD), odour nuisance, etc.).

(b) Process for Food/Fodder (Session Co-Moderator: D.G. Cunningham, Guelph)

Basically, there are two process strategies for the production of SCP/MBP (single cell proteins/microbial biomass protein) from lignocellulosics. One relies on liquid-state aerobic cultures (mainly *Candida utilis*) using hydrolysates containing both hexoses and pentoses; this is a well-established strategy with proven product acceptability. The other strategy that promises to be more economic, but is not yet established, uses a more direct solid-state fermentation (e.g., *Cellulomonas, Trichoderma,* and *Chaetomium* species).

An alternative approach to the food/fodder objective is mushroom cultivation, of which there are several options (various fruiting bodies) yielding tasty but slow-growing products. This area of activity is severely hampered by the lack of adequate feeding trial evaluations, possibly because of relatively high research

costs for evaluations such as toxicity, teratogenicity, nitrogen protein utilization (NPU), metabolizable energy (ME), with mice, rats, poultry, swine, cattle, etc.

(c) Processes for Liquid Fuels (Session Co-Moderators: G.G. Stewart, London; D.G. MacDonald, Saskatoon)

The traditional and major current approach to this option is the production of fuel-grade ethanol. Despite the global oil "crisis," this route remains uneconomical, primarily because of high pretreatment and recovery (distillation) costs and the inability to achieve adequate fermentation levels of pentoses even with the "best" cultures (e.g., with *Pachysolen tannophilus*) or enzyme combinations (e.g., immobilized glucose isomerase). Novel immobilized-cell bioreactors (e.g., *Saccharomyces cerevisiae, Zymomonas mobilis*) indicate certain technology improvements, but the overall process economics are still not good enough. So far, results on butanol/acetone and microbial fats and oils are even less promising despite active research in these areas.

(d) Processes for Gaseous Fuels (Session Co-Moderator: J.M. Scharer, Waterloo)

The production of biogas (60% v/v methane) from agricultural residues (mainly mixtures of manures and straw) for small-scale heating and illumination purposes has been successfully practiced in several developing countries (notably China, India) for many years. Larger-scale operations are more difficult to assess in terms of technoeconomic viability. A better understanding of this complex microbiological process is being sought to allow design and operation at optimal conditions. The effects of carbon/nitrogen ratios, bulk mixing, pH, temperature (mesophilic vs thermophilic ranges), process staging (acidogenic vs methanogenic phases) are actively being researched. Various bioreactor designs (free suspensions, sludge blankets, fixed-films, trickle beds, etc.) are also being compared. Other potential fuel gases, such as hydrogren, by bioconversion processes are in embryonic stages and have no meaningful place in the real world at present.

(e) General Considerations (Session Co-moderator: S.M. Martin, Ottawa)

There are many other factors besides the scientific and technoeconomic ones already mentioned that can "make or break" the application of a process. For example, geopolitical and cultural factors may become overridingly important in an unconventional food type. In addition, alternative chemical methods of producing fuel and food products must be compared to existing and proposed bioconversion ones.

In an attempt to provide some focusing, participants were also sent in advance five subdivisions of each of the session topics already discussed. Those subdivisions are identified in Table 1.

Results and Recommendations

- Overall, the conference is considered a failure in terms of generating new information. It may be considered a success for some groups (especially

those in developing countries) where the current scientific literature is not readily available. It was a limited success in introducing potential users to a "new" method of holding a scientific conference. The system was fairly easy to learn and use. However, it is possible that a simpler electronic mail system would have been adequate for most of the participants' needs; certainly it could have been much cheaper.

- It is probably wishful thinking to expect that the effectiveness of conferences of this type strongly depends on the input of the moderator and co-moderators. In this case study, participants rarely seemed to take cues

Table 1. Moderator's subjective ratings based on an increasing scale of 0–5 of the extent of new data presented and the discussion frequency of the various topics proposed.

	New data	Discussion frequency
Upstream process considerations		
Availability, types, and compositions of lignocellulosics	0	1
Physical and chemical pretreatment methods	1	3
Biological and enzymatic pretreatment methods	0	3
Production and characterization of relevant enzymes	2	5
Miscellaneous	0	2
Processes for food/fodder		
Liquid substrate fermentations	0	1
Solid substrate fermentations	0	2
Mushroom cultivations	1	3
Quality and application of products and byproducts	0	1
Miscellaneous	0	1
Processes for liquid fuels		
Systems for ethanol	1	3
Systems for butanol/acetone	0	2
Bioreactor design and operation	1	1
Quality and application of products and byproducts	0	1
Miscellaneous	0	1
Processes for gaseous fuels		
Systems for methane biogas	2	5
Systems for fatty acid intermediates	1	2
Bioreactor design and operation	2	5
Quality and application of product and byproducts	1	3
Miscellaneous	1	1
General considerations		
Process integration, implementation and economics	1	2
Materials of construction and plant maintenance	1	2
Geopolitical, cultural and related factors	2	4
Nonbiological process options	0	0
Miscellaneous	0	0

from the session moderators and often addressed issues of their own choice. In fact, there were examples of possible misuse of the medium for personal advertisements, etc., by participants. Admittedly, the session co-moderators could have played a more active role; indeed, except for the initial inputs of one or two co-moderators there were virtually no contributions from them in the later stages of the conference. In a conventional conference, there would have been less likelihood of this happening. This observation leads to the next point.

- The delegates in North America, including the co-moderators, who were "selected" to participate in the conference, are renowned researchers in this field. It is suspected that their lack of involvement is related to their usual busy schedules and, in particular, to the concern of new information being released before conventional "bona-fide" publication in journals. In this context, my own students decided not to continue in the conference after the first few weeks because "it was a waste of time" in terms of learning anything new.

- The rapporteur seemed to have had relatively little "hand-holding" to do during the conference since participants tended to solve their own technology problems. It may have been useful to have had preconference workshops for participants to give hands-on practice with the EIES system. During the conference itself many problems, which participants experienced on terminal hookups, etc., caused discouraging frustrations. The intended "hand-holding" function of the rapporteur is admirable but it became "a solution in search of a problem" in our case. However, the rapporteur was instrumental in "dumping" the relevant COM material into the EIES conference and vice versa, thereby allowing us to communicate with our Scandinavian colleagues.

- In general, the computer-based system offered a convenient asynchronous method for ongoing communications between laboratories around the world. For this computer system, lack of capability for readily presenting graphical illustrations, mathematical expressions, chemical structures, etc., placed a limitation on the conference. Backup regular mail is to be recommended. The cost of the EIES system itself is considered prohibitively high for this type of conference. In fact, one participant summarizes the general feeling: "at $75 per month, we can buy a lot of good journals which are more useful to us." Alternative systems should be checked.

- For virtually all the participants, this was their first experience with a computer-based conference. As expected, the initial period (May–June 1983) was primarily a slow learning process with relatively few participants in the system. By contrast, there was substantial "information overload" during the 1-week period (12–16 December 1983) of the concentrated "dispersed workshop" phase of the conference. (This phase also involved additional nonregular participants entering the discussion via 'nodes' having appropriate terminals in various countries.) In retrospect, a "limiter" mechanism for daily input lines would have minimized the overload problem.

- As indicated in the table, there was relatively little new technical information revealed during the conference. Regard for confidentiality and prepublication concern may have been deterrent factors. Attempts to pro-

mote a publication monograph of extended abstracts did not receive enough response. There was a tendency for repetitious debates, presumably because of the failure of these participants to check preceding discussions before entering the conference. Short of censoring inputs, it was difficult to prevent these.

Concluding Remarks

Despite the personal reservations on the outcome of the exercise, informal feedback indicated that participants were fairly happy with the experiment and have found it useful, mostly for the experience in computer-based networking rather than for any new scientific knowledge gained. In retrospect, a brief face-to-face meeting of the participants at an intermediate stage during the conference period would have been helpful in promoting improved on-line dialogue. However, until science and engineering researchers are convinced of the need/necessity to become literate in computer conferencing techniques, only the computer-prone managers of research contracts seem to be interested in using this medium, possibly because of its power to maintain records and generate progress reports fairly quickly. At present, I suspect that the average researcher would rather spend the time reading journals rather than learning about computer conferencing. In the interim, a simple electronic mail network should be encouraged.

At this stage, a follow-up conference is being considered, hopefully implementing a much less expensive and user-friendly system such as Cosy (based at Guelph) or CONTACT (based at Waterloo), on a much more focused topic, "criteria for a modular, transportable fermentation pilot plant." This is to complement a concurrent Scandinavian COM-sponsored one on "criteria for a modular, transportable lignocellulosic pretreatment pilot plant."

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