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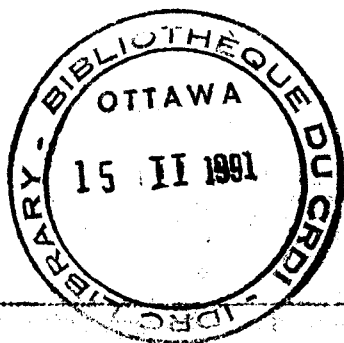
Computerized Communication Links for
Latin American Brucellosis Research Network

Background

Brucellosis is an infection caused by several species of Brucella micro-organisms that have their reservoirs in domestic animals. Brucella abortus causes abortion and decreased milk production in cattle. Brucella melitensis causes similar symptoms in sheep and goats. Brucella suis is found in swine and affects the genital organs of both sexes. Although human beings are not natural hosts for the Brucella germ, the disease is easily transmitted to them from the consumption of meats and products of infected animals. The disease manifests itself in humans by causing a debilitating recurrent fever that may last for months and can also be fatal. Brucellosis is a disease of livestock and man that causes serious social and economic problems especially in developing countries.

Vaccine research and production even for tropical diseases continue to be dominated by the industrialized countries. However, newly developed techniques using monoclonal antibodies represent a breakthrough in vaccine production and can readily be adopted for research on diseases in developing countries. As a model for applying these new techniques in biotechnology to the development of vaccines in Latin America and the Caribbean, brucellosis was chosen as the disease on which UNU-supported research and training should concentrate.

In October 1984, the UNU organized a workshop at the Animal Disease Research Institute (ADRI) in Ottawa, Canada, which brought together specialists on the disease for the purpose of developing a plan of action for the promotion of research in brucellosis. The workshop recommended that the UNU establish a co-operative research network involving institutions primarily in Latin America, as well as a computer electronic linkage among the participating institutions and hold annual workshops. Dr. B. Stemshorn, the Director of the ADRI was designated as the co-ordinator for the network. Later, he was succeeded by the current co-ordinator, Dr. Julius Frank, who was formerly the Director of the



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ADRI. Institutes in Argentina, Canada, Chile, Colombia, Ecuador, Peru, United Kingdom, United States and Venezuela were initially identified for participation in the network. At present the following institutions are actively participating in the network:

- Instituto Nacional de Tecnologia Agropecuasia, in Buenos Aires, Argentina
- Animal Disease Research Institute in Ottawa, Canada
- Universidad Austral de Valdivia in Valdivia, Chile
- Empresa Venezolana de Productos Veterinarios in Bogota, Colombia
- Instituto Colombiano Agropecuario in Bogota, Colombia
- Virginia-Maryland Regional College of Veterinary Medicine in Blacksburg, Virginia, USA
- Instituto Nacional de Higiene y Medicina Tropical in Guayaquil, Ecuador
- Escuela Nacional de Ciencias Biologicas in Mexico City, Mexico
- Instituto Nacional de Salud in Lima, Peru

The Instituto de Investigaciones Veterinarias in Maracay, Venezuela was one of the original participating institutions. It decided to leave the network in 1989 owing to the difficulty of the main researcher to continue her collaboration in the UNU project. The microcomputer and modem provided under the project to their institute were subsequently returned to the UNU. The equipment will be used to link another appropriate laboratory in Latin America to the network.

In subsequent workshops that were held in Chicago, USA in 1985 and 1986, the network participants had the opportunity to present their findings and to familiarize themselves with the research activities of their colleagues in the network. UNU provided the financial support for the workshops and the co-ordination required for the network. In addition, each participating laboratory was given a small grant by the UNU for the support of research activities. These grants were primarily used for the procurement of laboratory supplies and reagents from overseas. The UNU also provided training opportunity for the

network participants. To date, a total of six individuals from the participating institutions in Latin America received UNU fellowships with durations of 3-6 months to undertake research and learn new laboratory techniques at the ADRI in Canada, Virginia - Maryland, Regional College of Veterinary Medicine in U.S.A. and the Centro Panamericano de Zoonosis (CEPANZO) in Argentina.

Computerized Communication Links

Following the establishment of the Brucellosis Research Network, a generous grant was obtained from the International Development Research Centre (IDRC) of Canada, in 1985 for setting up a computerized communication system among the participating laboratories in the network. The overall objectives of this project were: to test and evaluate the use of computerized communication techniques in support of the research network; to strengthen indigenous research capability of the institutions in Latin America involved in the network; and to promote co-operations among researchers in brucellosis both in developing and industrialized countries.

Under the IDRC grant, the participating laboratories in Latin America were provided in the summer of 1987 with microcomputers, printers, modems, software and other facilities needed to link with a central computer service called the Electronic Information Exchange System (EIES), a commercial mainframe computer in New Jersey, USA. Two consultants, Mr. Soledad Robina from Mexico and Mr. Gabriel Rodrigues, from Chile were employed in the summer of 1987 to help install the microcomputers and provide the training in the use of the microcomputer for electronic mail using EIES. Further training in use of the EIES electronic mail and conferencing system was given at the annual workshop held in Valdivia, Chile in October 1987.

In October 1987, the UNU commissioned Dr. Warren Thorngate, Professor of Psychology at Carleton University of Canada to design a monitoring and evaluation methodology and to evaluate the effectiveness of the computerized links. The final report of his consultancy assignment, which was continued until the end of the project period, is attached to this narrative report. The highlights

of the consultancy report are given as follows:

- Most of the network participants make frequent and regular use of the electronic mail facility. In contrast, very little use was made of the conferencing facility.
- Electronic mail is most often utilized for seeking information on scientific techniques used for diagnostics and preparation of reagents and cellular extracts in attempts to produce vaccines.
- Computer communication is used to facilitate arrangements of the annual workshops. As a result, the efficiency of the scientific meetings may have been increased. The consultant observed that some electronic mail is used to serve social needs which may have contributed positively towards the good comradeship that exists among the network members.
- EIES is expensive and difficult to use. It provides limited access to the larger academic community as it is not connected to other computer networks such as BITNET.
- Local telephone connections are expensive and unreliable.
- It is difficult and expensive to repair broken equipment.

Dr. Thorngate was kind enough to go beyond the terms of his consultancy contract and seek ways of ameliorating some of the difficulties encountered with computer communication links using EIES. He undertook to search for an EIES alternative that will serve the needs of the network after the termination of the support from IDRC. He succeeded in getting a donation of \$10,000 of computer time from Carleton University for connecting the network to BITNET. With this arrangement in place, he proceeded to establish an account on the Carleton University computer for each member of the Brucellosis Research Network and wrote a user's manual in English. The manual was subsequently translated into Spanish.

At the last workshop held in Caracas, Venezuela in April 1990, Dr. Thorngate reported that all of the participating institutions in the network with the exception of the one in Ecuador have been successfully connected to BITNET through the Carleton University computer. The collaborating institution in

Ecuador has not been able to establish a good telephone connection outside the country. Since Ecuador does not have a national Packet Switching Network, the connection to the Carleton University mainframe computer must be made through a long distance telephone call.

Dr. Thorngate's report describes in some detail, some important lessons learnt from the computerized communication project. His finding shows that scientists in developing countries working in related areas of research will make reasonably good use of computer communication facilities to supplement more traditional means of communication. He believes that this will translate into increased efficiency of activities. One may also add that computerized communication helps alleviate the isolation that scientists in developing countries often face. The mail system in many developing countries is quite unreliable. Dr. Thorngate has enumerated the following prerequisite conditions that must be met in order to make computer communication successful in developing countries.

- Proper communication equipment - at the very minimum, a microcomputer with two disk drives, a monitor and a printer that run on local electric current and a modem that works with the local system are needed.
- Reliable communication links - a private telephone line with an account with the local Packet Switching Network or a reliable long distance connection is mandatory.
- Equipment must be easy to maintain and quick to repair.
- Users must be given "hands-on, on-site" training.
- Network participants must be familiar with as many of the other members as possible and must share related research interests. Dr. Thorngate emphasizes that his medium of communication cannot serve to replace face-to-face meetings.
- A network must have someone to serve as co-ordinator.

Brucellosis Research

As indicated earlier in this report, UNU's support to the network has not been limited to the establishment of computerized communication. Since 1984, the UNU has continued to provide the services of a consultant to co-ordinate the research activities of the Brucellosis Research Network. In addition, the UNU has made available small research grants to the network participants for the primary purpose of procuring much-needed supplies and reagents from abroad. During the life of the project a total of six workshops were organized with UNU support. The UNU has provided a total of six fellowships with 3 to 6 months duration for training in newer research techniques. These fellowships were tenable at institutions in Argentina, Canada and USA.

The 1988 workshop held in Buenos Aires, Argentina has resulted in a monograph manuscript which brings together the research outcome and computerized communication experience of the network. The manuscript entitled, "Networking in Brucellosis Research" consists of 24 chapters dealing with the bacteriological, immunological, serological and biochemical aspects of Brucella abortus. In addition, one chapter each is devoted to general considerations of the pathogenicity of Brucella suis and Brucella melitensis. The computerized communication experience of the network is described in one chapter authored by Dr. Thorngate. The manuscript has been favorably assessed by external reviewers and is expected to be published soon.

The UNU intends to continue providing limited assistance to the network as long as this is needed and the UNU is able to mobilize the necessary resources. As indicated in Dr. Thorngate's consultancy report, it is not realistic to expect the network to function without limited support to cover co-ordination and communication expenses. Limited support to cover the expenses for co-ordination of the network and the annual workshops will be provided under the UNU Regional Biotechnology Programme for Latin America and the Caribbean (BIOLAC). As a matter of fact, the latest workshop held in Caracas, Venezuela in April 1990 was organized under this new arrangement. The UNU is not, however, in a position to provide a substantial support for the research activities of

the members of the network because of budgetary constraints. Funds for this purpose will have to be raised from external sources. In this regard, the UNU is in the process of negotiating a contract with Supply and Services Canada for undertaking a project entitled "Study of Vaccination and Treatment against Brucella spp". The project is expected to have a budget of Canadian \$140,000 over a two-year period and will involve the active participation of the members of the Brucellosis Research Network. It is hoped that the participating laboratories will benefit significantly from inputs to be provided under the contract.

Final Report of the
Brucellosis Computer Conference

submitted by

Warren Thorngate, Professor
Psychology Department, Carleton University
Ottawa, Ontario, Canada K1S 5B6

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Background

In mid-1987 the United Nations University (Tokyo) and the International Development Research Centre (Ottawa) invited about 15 scientists engaged in Brucellosis research at eight sites in Latin America¹ and one in Canada to participate in a scientific communication experiment: exchanging information about their common research interests via an electronic mail and computer conferencing network. During the summer of 1987, each site was equipped with a microcomputer, printer, modem, and an account on the Electronic Information Exchange System (EIES), a commercial mainframe computer in the United States (New Jersey) that served as the hub of the Brucellosis Network and the depository of all electronic mail and conferencing messages. Much of the microcomputer installation and electronic mail training was done by two consultants, Soledad Robina (Mexico) and Gabriel Rodriguez (Chile), who documented their experiences in their report, Microcomputer Network Between Latin American Brucelosis Laboratories, dated August 1987.

In October 1987, UNU and IDRC commissioned me to evaluate the experiment by monitoring the use, problems, costs, and scientific effects of these new communication media. That month I attended a face-to-face, scientific conference on Brucellosis held in Valdivia, Chile that included all Brucellosis network members. During the conference, Walter Kelly, a senior computer administrator from the Canadian site (the Animal Diseases Research Institute, of ADRI), provided further training on use of the microcomputers and on the EIES computer conferencing system. I spoke to participants about the concepts, uses and etiquette of computer conferencing, and distributed a user questionnaire. Thereafter, I monitored electronic mail and conferencing traffic, and communication costs (see Table 1). A second face-to-face conference was held in

¹Argentina, Chile, Columbia (2), Ecuador, Mexico, Peru, and Venezuela. In the fall of 1989 the site in Venezuela was replaced by a second site in Argentina.

Table 1. EIES Expenses

Month	User/Site:											Ln	Am	T	Total
	296	307	312	313	316	320	322	323	326	328	CONFR				
03-87					\$4.53				\$40.72	\$9.07			\$4.53		\$54.32
04-87	\$50.50				22.53				19.95	51.98			\$73.03		\$144.96
05-87	11.20				16.32		\$7.21		21.81	15.16			\$34.73		\$71.70
06-87	19.66	\$25.10	\$23.51	\$8.26	21.73	\$9.21	27.67		32.61	35.49			\$135.14		\$203.24
07-87	10.00	16.50	33.95	10.00	21.68	13.88	19.58		43.10	26.38			\$125.69		\$195.17
08-87	39.68	12.40	24.29	10.00	13.35	10.13	14.79		30.70	27.92			\$124.64		\$183.26
09-87	39.92	12.66	21.18	10.00	20.17	11.59	20.11		51.89	151.00			\$135.63		\$338.52
10-87	24.97	13.36	37.74	10.00	62.96	12.97	26.30	\$10.15	44.14	218.76	\$0.19		\$198.45		\$461.54
11-87	12.35	10.00	17.06	10.00	17.73	11.32	10.66	3.66	21.47	68.18	25.00		\$92.78		\$207.43
12-87	10.00	11.12	26.72	10.00	14.85	10.53	34.65		23.77	243.62	25.00		\$117.87		\$410.26
01-88	10.00	10.26	10.93	10.00	18.51	11.95	10.92		22.81	136.98	25.00		\$82.57		\$267.36
02-88	10.00	14.66	10.00	10.00	10.63	10.92	12.66		20.43	70.40	25.00		\$78.87		\$194.70
03-88	11.86	14.40	32.89	10.00	49.60	11.86	14.11		14.12	211.30	25.00		\$144.72		\$395.14
04-88	11.80	12.26	11.85	10.00	15.29	11.62	18.25		11.97	172.95	25.00		\$91.07		\$300.99
05-88	10.00	10.00	10.00	10.00	44.16	10.87	17.95		14.55	79.27	25.00		\$112.98		\$231.80
06-88	10.00	10.00	10.00	10.00	57.37	11.80	15.32		15.76	68.72	25.00		\$124.49		\$233.97
07-88	10.00	10.00	13.23	10.00	36.89	10.91	12.38		13.99	29.96	25.00		\$103.41		\$172.36
08-88	11.91	13.57	25.24	10.00	17.19	11.44	15.80		18.02	46.87	25.00		\$105.15		\$195.04
09-88	10.00	10.00	31.20	10.00	52.64	11.19	23.11		16.76	78.52	25.00		\$148.14		\$268.42
10-88	16.15	10.00	17.93	10.00	67.45	13.37	25.95		18.22	102.06	25.00		\$160.85		\$306.13
11-88	(missing data)														
12-88	13.24	10.00	26.22	10.00	232.96	11.13	13.49		15.55	63.29	25.00		\$317.04		\$420.88
01-89	15.67	10.00	30.76	10.00	114.31	11.34	14.35		22.06	53.91	0.37		\$206.43		\$282.77
02-89	14.52	10.00	31.19	10.00	11.79	10.61	13.21		13.92	41.75			\$101.32		\$156.99
03-89	10.00	10.00	26.73	10.00	26.15	10.30	11.25		13.40	29.07			\$104.43		\$146.90
04-89	10.31	10.00	25.23	10.00	22.57	11.06	11.11		17.40	23.85			\$100.28		\$141.53
05-89	10.00	24.15	25.13	10.00	58.46	11.79	14.83		12.84	60.54			\$154.36		\$227.74
06-89	16.49	10.48	17.85	10.00	79.97	10.00	10.46		17.25	24.77			\$155.25		\$197.27
07-89	11.95	10.00	16.26	10.00	135.82	14.40	22.46		16.84	33.54			\$220.89		\$271.27
08-89	10.00	10.59	12.48	10.00	22.56	35.78	10.60		15.58	54.82			\$112.01		\$182.41
09-89	17.31	10.15	19.69		65.70	28.58	12.10		17.43	33.29			\$153.53		\$204.25
10-89	10.00	16.93	10.46		45.88	19.08	10.00		19.12	17.84			\$112.35		\$149.31
monthly	15.65	12.45	21.42	9.93	45.22	13.20	16.25	6.91	21.88	73.59	21.70		126.86		232.83
total	469.49	348.59	599.72	258.26	1401.75	369.73	471.28	13.81	678.18	2281.26	325.56		3932.63		7217.63

NB: Monthly totals do not include \$250 per month "project fee"

Buenos Aires in December 1988. There I spoke on network use, held a group discussion about the future of the network, and distributed a second user questionnaire.

My audits of EIES usage and of the opinions of Brucellosis network members are summarized in three previous reports: Interim Report on the Brucellosis Computer Conference, June 1988; Patterns of Computer Communication: A Report on Brucella Network Activity, December 1988; and Second Interim Report of the Brucellosis Network Project, June 1989. These reports document four major findings:

1. most Brucellosis Network members use electronic mail frequently and regularly, but they do not use computer conferencing;
2. electronic mail is most often used for questions and answers regarding technical aspects of scientific work, and for arranging face-to-face meetings;
3. some electronic mail is social, and it serves an essential function in maintaining the social bonds of network members;
4. use of the network significantly increases the efficiency of face-to-face meetings, and modestly increases scientific productivity.

In addition, the reports document three major concerns.

1. EIES is expensive and difficult to use. It is not connected to other computer communication networks such as BITNET, so it provides limited access to the larger scientific community. In addition, its use drains funds from developing countries and contributes to United States domination of the means of information exchange.
2. Local telephone connections are expensive and unreliable. They cause network members great inconvenience, and have prevented one member (in Ecuador) from ever using the communication facilities.
3. Broken equipment is difficult and expensive to repair.

Without exception, Brucellosis Network members have greatly appreciated the temporary funding of their computer communication experiment, and would like to

continue using the medium. Yet the experiment itself has created a dilemma worthy of mention. If Network members do not use the medium, then the experiment will fail and funding will cease. Yet if they do use the medium and come to rely upon it, they will create a demand for further funding. If funds are unavailable, they will lose access to the medium, and thus squander the time and effort they invested in the experiment. If funds are limited, communication funding will likely be diverted from research support. But with less research support there will be less research to report -- research that fuels the demand for computer communication. They may, in short, be forced to choose between the medium and the message even though both are necessary for effective research.

In response to the robust use of electronic mail and to the concerns about EIES, I undertook to search for EIES alternatives that could maintain the network past the 20 December 1989 termination of UNU/IDRC funding. The best one I found was at Carleton University, my home institution; it provided much less expensive electronic mail facilities than EIES, and connections to a worldwide academic computer communication network called BITNET. Carleton University donated \$10,000 to the Brucellosis Network for faculty accounts on a campus mainframe computer. The accounts allow Network members to send and receive electronic mail messages among each other just as they had done on EIES. In addition, because Carleton is a member of the BITNET academic computer communication network, members can communicate with over 2,000 other BITNET institutions and thus with over 200,000 researchers around the world.

The "Carleton solution" is only temporary. BITNET is expanding rapidly in many Latin American countries (e.g., Brazil, Chile, Mexico). I expect that within two years most of the Network members will have access a BITNET connection through local university or other institutional computer facilities. They can then exchange information among one another without linking to a Canadian computer, but can still communicate with Canadian and other colleagues beyond Latin America.

After establishing a Carleton computer account for each Brucellosis Network member, the next task was to connect each of them to the machine. I wrote a user manual in English during June/July 1989 that discussed methods of establishing communications between Latin America and Carleton, how to use the Carleton electronic MAIL programme, the nature of BITNET and how to use it. My assistant, Bat-Ami Klejner, translated the manual into Spanish. Both versions were sent to Network members in August, 1989.

Recent Developments

On 19 November 1989 I sent a progress report on Carleton connections to Dr. Abraham Besrat at the United Nations University via BITNET. As noted therein, by mid-November the following sites had successfully established contact with Carleton:

1. ADRI in Ottawa, Canada;
2. Valdivia, Chile;
3. one of two in Bogota, Colombia;
4. one of two in Buenos Aires, Argentina;
5. a new temporary site in Trinidad (one member from Ottawa who is on leave there).

The member from Peru and the member from Ecuador were working at ADRI in Ottawa from August until October 1989. While there, Ms Klejner and I instructed both of them how to use the Carleton MAIL/BITNET system. Because the member from Ecuador has never been able to establish a good phone connection beyond his country's borders, I do not expect him to use the Carleton facility. The member from Peru is a computer enthusiast, and I expect him to reach Carleton from Lima within a month.

Since the progress report, the second Bogota member and the member from Mexico both established contact with Carleton. The three members in Valdivia, Chile began to communicate using their new local BITNET connection at their own Universidad Austral. The remaining member in Buenos Aires continues to await the repair of his modem.

When repaired, he will use the same connection procedures as his succesful colleague across town, so I expect he will have no trouble making the Carleton connection.

By happy coincidence, Ms Klejner was raised in Buenos Aires, and during the past six months her father-in-law has been sending her BITNET messages from there using a public computer communication system in Argentina called Delphi. Bat-Ami has returned to Buenos Aires for Christmas holidays. While there, she will obtain information about Delphi accounts and meet the two Brucellosis Network members to pass it on. Delphi is rumoured to be relatively inexpensive, and thus may provide a good local alternative to the direct Carleton connection. Like the local BITNET connection at Austral, this is the sort of local link to BITNET I hope all Brucellosis researchers can eventually obtain.

In sum, all Brucellosis Network members except the one in Ecuador have now established, or will soon establish, computer communication links with Carleton. I am thus inclined to conclude that the transition from EIES to Carleton has been successful. It is a fitting conclusion for a largely successful communication experiment.

Lessons Learned

The Brucellosis Network experiment shows that committed scientists in developing countries working on related projects will use computer communication to supplement more traditional communication channels, and to increase the efficiency of their activities. However, the experiment also teaches us that they will not do so unless and until the following conditions are met.

Proper communication equipment must be available. Minimally, this includes a microcomputer with two disk drives, a monitor and a printer that run on local electrical currents, and a modem that works with the local modem protocol (Bell or CCITT). Often the equipment must be obtained locally, either to conform with local electrical connections, to avoid customs duties and delays, or to secure some measure of local service. When obtained locally, one must expect to pay from 2-5 times the cost of equipment purchased in a developed country. Before purchase, relevant colleagues of the

users should be consulted, a secure location for the equipment should be found, and rules of access should be established. Such preparations will reduce the chances of territorial disputes regarding equipment ownership and use.

Reliable communication links must be obtained. A private telephone line is necessary for the modem so others will not use party lines during computer communication sessions and destroy the computer connection. An account on the local Packet Switching Network, or a reliable long distance telephone connections is an obvious necessity. Lines often cost over \$1,000 US, plus monthly charges, and often take over a year to install. Accounts on Packet Switching Networks are equally expensive and slow to obtain. One must therefore begin to plan the establishment of a computer communication network at least one year in advance of its use.

Equipment must be easy to maintain and quick to repair. It sometimes can take more than a year to repair equipment in developing countries if, indeed, it can be repaired at all. At least two strategies are possible to reduce this unacceptable delay. First, an equipment exchange depot can be established to provide a place where malfunctioning equipment can be sent for immediate exchange with functioning equipment. Alternatively, all equipment can be purchased in pairs so one of the pair can serve as a backup while the other was being repaired.

Users must be given "hands-on, on-site" training. Computer communication links in developing countries will probably remain primitive, unstandardized and confusing for another decade. Computer communication will thus continue to require good, local, on-site training. Contrary to some popular images, scientists do not usually take to computer communication like ducks to water. Many excellent scientists remain confused and frightened by the medium, so it is naive to expect them to become proficient merely by reading user manuals. To make good use of the medium they must learn to push the correct buttons under the personal supervision of a competent instructor. Fortunately, as

the number of knowledgeable users grows, so too does the number of persons who can serve as competent instructors. Local persons with knowledge of local computer communication conditions and a knack for training are ideally suited to train others.

Network members must know at least some of the other network participants. The Brucellosis Network has been successful in large part because its members knew and liked each other in advance of the network experiment. Previous research has shown that equal success is difficult to obtain among people who are unacquainted. There are several interesting social psychological reasons for this, leading to the conclusion that computer communication is more conducive to maintaining working relationships than to developing them. Personal contact is needed to form the personal friendships that sustain computer communication. The medium cannot serve as a replacement for face-to-face meetings; it is best seen as a replacement for most regular mail.

Network members must share related research interests. It is axiomatic that communication cannot occur unless participants have a reason to communicate and share a common universe of discourse. Perhaps ideally, all scientists in a computer communication network would be working on exactly the same research project, and thus have both the reason and the background to communicate. This ideal almost never occurs. Far more common are groups like the Brucellosis Network: members have related but not identical interests; they are working on different research projects². I suspect that Brucellosis Network members were reluctant to use computer conferencing largely because there was almost nothing at the intersection of all of their interests except perhaps concerns about future research funding. Instead, members A and B would exchange electronic mail messages about their mutual interest in X, B and C would exchange messages about their mutual interest in Y, A and C would exchange messages about their mutual interest in Z, etc. No one yet knows just how much, or how little,

²Brucellosis Network members' research ranged from gene splicing to cattle counting.

overlap is necessary to sustain a research network. But we do know that sustaining a research network using computer communication is no less difficult than sustaining one with newsletters, annual meetings, or any other traditional medium.

A network must have a full-time coordinator. Computer communication networks do not run themselves, and we now know enough about them to understand why it is foolish to believe that a coordinator is unnecessary. Someone must be responsible for encouraging participation, for answering technical questions, for arranging training, for obtaining and updating computer accounts, for sending requested materials, and for administering the funds that pay for the medium. Though the Brucellosis Network was quite small, administration of its computer communication activities required about 10 hours per week of the collected time of Bat-Ami Klejner and me. Larger networks would, of course, require proportionally more effort. Few, if any, active scientists would volunteer to provide this effort; even if they did, they may not be well trained for their tasks.

Implications for Communication Funding Policies

In 1987 Halla Thorsteinsdottir, a Masters student working under my supervision, wrote her thesis on computer communication funding policies of agencies supporting research in developing countries. Her survey of these agencies indicated that none had a clear funding policy; indeed, requests to fund computer communication projects such as the Brucellosis Network seemed to take most of the agencies by surprise. Agencies that were trying to develop funding policies were inclined to believe that computer communication should be funded on a project-by-project basis, and that researchers should budget monies for use of the medium as an extra item in their normal research grant proposals.

From the perspective of a funding agency, project-by-project funding is probably a good strategy because it minimizes the chances of putting all funding eggs in the wrong communication basket. Yet the lessons taught by the Brucellosis Network experiment

suggest that this funding strategy is not a good one for scientists. Until developing countries build communication infrastructures as extensive and reliable and those in the developed world, computer communication networks will be difficult to establish and maintain. Even modest networks will require at least a year of intensive effort to create, and a considerable amount of knowledge and experience to administer. It seems wasteful to require each new group of scientists wanting to form a network to build their own from scratch. It is foolish for good scientists to take a year or more from their careers in order to create a temporary network for themselves that will disintegrate with the end of project funding. If communication were funded as an adjunct to research, then scientists without funding would be denied access to a network that might help them obtain future funds. Impoverished scientists would then become poorer while the rich ones exchanged electronic mail.

A traditional alternative to project-by-project funding is infrastructure funding. It is possible to support large communication development projects that would create the technical infrastructure necessary for reliable and convenient computer communication. The infrastructure would be maintained and administered by computer communication specialists, and offered at minimal cost to working scientists as part of their membership in the scientific community. BITNET and its sisters (JANET, EARN, NETNORTH, OZNET, etc.) exemplify this structural alternative within the academic community of the developed world. There is much to be said for it, and some is said in my Second Interim Report. Yet it has at least two drawbacks. First, support of a technical infrastructure does not solve the problems or reduce the effort associated with the social structure of computer communication; someone must still develop and maintain each scientific group. Second, support of a technical infrastructure does not come cheap, and can easily drain the financial resources of even the most well-endowed agency.

Given the advantages and disadvantages of project-by-project and infrastructure

support, it is probably sagacious to fund some of each. If so, then one must determine how best to distribute the funds. This may not be as difficult as it first appears. In Latin America, for example, it is likely that over 90% of all scientists work within 50 KM of one of 200 educational or equivalent institutions. The mainframe BITNET links to these institutions could be subsidized in exchange for creating computer accounts and training scientists who wished to join. Individual scientists could receive project funding for computer equipment, communication charges, and coordinator assistants in exchange for obtaining local training and for demonstrating use of their BITNET account.

The Future

I think such a mixed strategy would work well in places with a local BITNET or equivalent connection, and with reliable local telephone lines. Some countries (e.g., Brazil) have several such places. Alas, more countries don't. Because Ecuador, for example, does not have a national Packet Switching Network, the country cannot support even one connection to BITNET that could in turn serve several scientific groups forming small computer communication networks. Argentina has a national Packet Switching Network, but it is plagued by terrible local phone connections. Either or both problems also exist in Bolivia, Paraguay, Venezuela, and almost all African countries. It seems unreasonable for any agency funding scientific research to spend money on the development of national Packet Switching Networks or on improving local telephone lines; one may as well fund the redevelopment of entire national telephone systems! Yet, without some reliable computer communication links, scientists in the majority of developing countries will be excluded from the medium.

What to do? One possibility is to develop an alternative to unreliable and expensive local telephone systems that would allow scientists to link to some existing BITNET or equivalent connection. A relatively new communication medium shows great promise as this alternative: packet radio. Developed over the past 10 years by amateur "ham" radio

operators, packet radio allows inexpensive short wave stations to send and receive the sounds of modems rather than the sounds of voices, and thus to "leapfrog" the local phone lines. In simplest form, their operation is quite straightforward. Special software converts the text output of a microcomputer into "packets" of information that would normally be sent via a commercial Packet Switching Network. The packets go through the computer's modem which is plugged into a transceiver about the size of a standard dictionary. The transceiver is connected to an antenna about 2 metres long. Packets are transmitted over international amateur radio bands to a maximum distance of about 50KM. All transceivers within this radius can receive the packet transmission, but additional software filters out all packets but those addressed to a receiving station.

Packet radio technology is well-proven, reliable, and relatively inexpensive. Several packet radio networks now exist around the world; there are, for example, hundreds of packet radio operators in North America, and a growing number (perhaps 50) in Argentina and Chile. The modems and radios can run on batteries, and are entirely portable. A transceiver, modem and software package can be obtained for about \$2,000 US -- often about the cost of one phone line installation and rental for one year. If a packet radio were connected to a mainframe computer at a BITNET site, then scientists with their own packet radios who worked within the transmission radius could avoid the problems of local telephone lines. This could greatly increase BITNET accessibility.

Scientists far from a BITNET site might well benefit from a new extension of packet radio: packet satellite radio (PACSAT). Again developed by ham radio operators as an alternative to expensive commercial satellite communication, PACSAT operates through inexpensive, portable ground stations that literally "beam up" information to amateur radio satellites, and receive information from them. The satellites are launched in low (300-400KM) polar orbits, so as the world turns they overfly each point on earth three times a day. Inside each satellite is a transmitter, receiver, and special microcomputer with lots of memory and enough intelligence to know where the satellite is and when it

will be over designated locations. When the satellite flies over one ground station (for example, in Addis Ababa), the station operator there can beam up several message packets addressed to different persons around the globe. When the satellite is over each location (for example, in Caracas), it will automatically transmit the appropriate message(s) to the relevant ground station, which in turn can beam up its own messages for electronic delivery. This "store and forward" satellite capability allows scientists with packet radios to maintain international connections.

Though somewhat different radios and antennas are need for PACSAT, the radio equipment for a ground station costs no more than about \$3,000 US. A fully-featured PACSAT ground station with a dedicated microcomputer, appropriate software, and links to local packet radio transceivers should cost no more than about \$15,000 US. Such a ground station could be operated as an electronic mail gateway in any country without a commercial or affordable Packet Switching Network. If the gateway were located within a 50KM radius of many scientists, then the scientists could employ their own microcomputers and packet radios to reach the gateway that would in turn relay their messages to a PACSAT and around the world.

Many tactical issues must be resolved before packet radio or packet satellite radio can become a common and useful part of international scientific communication. But I think the medium holds sufficient promise to warrant further study and research support. In this regard, I have recently received a small grant from the Dean of Social Sciences at Carleton University to obtain better estimates of the costs and logistics of operating about five experimental PACAST ground stations in Latin America, Africa, and at Carleton. My project assistant, Doug Yuill (a Carleton library staff member and head of the amateur radio group in Ottawa), and I have engaged the cooperation of Dr. Flavio Llanos (professor of computer science and coordinator of the BITNET node at Universidad Austral de Chile), Dr. Casimiro Garcia (a director of CEPANZO in Buenos Aires and an

amateur radio operator), and Dr. Olga Marino (chief Brucellosis scientist at the Instituto Colombiano Argoppecuario in Bogota) to serve as ground station operators if and when the stations are obtained. We hope to secure the cooperation of Dr. Camilo Daza at BIOLAC in Caracas, and of Dr. Nancy Hafkin at PADIS in Addis Ababa to serve in the PACSAT ground station experiment as well.

Mr. Yuill and I are now constructing a PACSAT ground station with connections to Carleton's mainframe computer; it will be Canada's first PACSAT gateway. Six new PACSAT satellites will be launched on 10 January 1990: four of them, called Microsats, were developed in the United States; two, called UoSATs, were developed by the University of Surrey in England. We have obtained permission to use the Microsats for preliminary communication experiments (Carleton to Carleton), and are now making arrangements to use the more sophisticated UoSATs for the same purpose.

Our goal is to test PACSAT ground stations in the above mentioned sites during 1990-91. At the moment, therefore, we are seeking funds from international agencies to support our ground station experiment. If the medium is found to be cost effective, our next goal is to arrange for the construction and launch of more and better satellites to accomodate the electronic mail traffic of scientists from developing countries. Judging from the costs of building the Microsats, we believe a next-generation satellite can be constructed here in Ottawa for less than \$100,000. Preliminary talks with Soviet representatives indicate that such satellites could be launched from their country for very reasonable prices. The administration of an international PACSAT development project would surely be a daunting challange. But following my initial skepticism, I now believe that it can be done, and that it can provide greatly needed communication links for scientists in developing countries.

Presentations and Publications Arising from the Project

Thorngate, W. An Introduction to Computer Conferencing. (Paper presented at the first meeting of the Brucellosis Research Network, Valdivia, Chile, October 1987).

Thorngate, W. Patterns of Computer Communication. (Paper presented at the second meeting of the Brucellosis research network, Buenos Aires, December 1988; to be published in the conference proceedings).

Thorngate, W. Computer mediated communication in developing countries. (Paper presented at the founding meeting of the International Society of Communication Psychology, Leningrad, July 1989).

Thorngate, W., & Klejner, B. Developing Countries and Computer Communication: A Latin American Example. (Paper presented at the third Guelph symposium on computer mediated communication, Guelph, Canada, May 1990; to be published in the symposium proceedings).