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INTERNATIONAL CONFERENCE ON TECHNOLOGY TRANSFER

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TECHNOLOGY TRANSFER IN CANADA

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Contents

See 5.3

* Participant in the conference on behalf of Dr. Josef Kates, Chairman, Science Council of Canada.

1. INTRODUCTION

The transfer of technology from the place of invention to the place of application is a common process. For countless centuries the influence of particular cultures was delineated by the use of their characteristic technologies. In our modern industrial civilization with its high rate of innovation, the process of technology trnasfer has become virtually continuous in time, as well as global in extent. In Canada, industrial development - especially in secondary manufacturing industry - has been based on imported technology to an exceptional degree. The very volume and diffuse nature of this process makes it difficult to present an accurate picture of the situation in Canada as a whole. In addition, technology transfer has occurred either spontaneously, or as an incidental element of particular industrial or military programs. The consideration of the exact nature of the effect which such unrelated transfers (or lack of them) might have on our economic and defence position is a recent development. The fact that a significant cumulated effect was becoming increasingly apparent led the Science Council of Canada to investigate the situation.* Our studies have been concerned with the economic rather than the defence implications. The publications which resulted from, or are relevant to, these studies are listed at the end of this paper.

Some of the results of the Science Council studies are summarized below. We have assumed that Canada's participation in international cooperation projects is known to you, so attention will be focussed on internal experience.

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* The Science Council of Canada is a group of 25 senior scientists, engineers and managers (mainly from universities and industry), who are appointed by the Government to serve the nation by making recommendations on the development and use of scientific and technical resources for public benefit.

2. GENERAL COMMENTS

Technology transfer is a multi-valued term, hence it is necessary to define the interpretation given to it in this paper. In the Council's work, we have accepted Brooks definition, which states that technology transfer takes place whenever technical knowledge, a technique or a device which emerges from, or is developed by, one group becomes taken up and used or applied by another. According to this definition, the term covers both hard technology (material devices and designs of such devices) and soft technology (inventive ideas and the know-how needed for implementation of such ideas).

The process of technology transfer involves at least two partners (the source and the receiver) and one or more mechanisms. The general categories of partners are industries, universities and governments, both domestic and foreign. Recognizing that there are several types of industries with different characteristics and several levels of government, the total number of combinations of partners is so large that it is very difficult to describe the general ~~lack~~ state of technology transfer in a country. We have found that even within one category of industry, and one level of government, the attitude and performance often change quite drastically from one company or establishment to another. Hence examples given below should be treated as characteristic rather than typical, while any general statements are broad descriptions.

3. TECHNOLOGICAL INTERDEPENDENCE

Among the categories of sources and receivers, we have selected for discussion secondary manufacturing industry and federal laboratories, because of some special characteristics of these groups in Canada. Tables 1 and 2 shed some light on these characteristics. We see in Table 1 that, in 1973, gross expenditures on R & D (GERD) in Canada, as a percentage of gross domestic product (GDP), were rather low in comparison to the average for seven industrialized countries. Looking at the breakdown of these expenditures by sector of performance, we find that expenditures within government are slightly higher than the average, but that those in industry are very significantly lower and are responsible for the low total value. This is an indication of the fact that Canadian industry relies on technology transfer, rather than on intramural R & D, to a much greater degree than industries in all the other countries shown. It is industry's response to the relatively low profitability of industrial R & D in Canada. The reasons for this situation are many, including high costs of R & D and low capacity of the domestic market, but the principal cause may be related to the exceptionally high degree of foreign ownership in Canadian industry. The ownership structure is shown in Table 2. It happens that a foreign-owned or a multinational company can often optimize its profits by doing very little R & D in its Canadian branch plant, hence the connection between foreign ownership and low intensity of R & D in domestic plants. A full analysis of this relation is beyond the scope of this paper, but the point had to be made, as it will influence the subsequent discussion.

TABLE 1 - GERD as Percentage of GDP by Sector of Performance - 1973

	Industry	Government	University*	Total
United States	1.61	.38	.46	2.45
Germany	1.20	.32	.44	1.96
Netherlands	1.01	.39	.48	1.88
France	.99	.42	.29	1.70
Japan	1.00	.21	.44	1.65
Sweden	1.04	.16	.44	1.64
Italy	.64	.21	.21	1.06
Average	1.07	.30	.39	1.76
Canada	.39	.40	.34	1.13

* Includes Private Non-Profit

Sources: OECD, International Statistical Year 1973, Paris, September 1976. Vol. 5, pp. 41-42

OECD, Observer, no. 74 March/April 1975, p. 22

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TABLE 2 - Foreign Ownership Breakdown in Canadian Manufacturing Based on Value of Shipments (1970); Selected Groups

	Per Cent		Per Cent
Petroleum and Coal	97.9	Electrical Products	64.6
Transportation Equipment	86.8	Non-Metallic Minerals	51.6
Chemicals	81.3	Paper and Paper Products	49.3
Rubber and Plastics	72.7	Textiles	46.8
Machinery	71.6	Primary Metals	45.9

Source: Statistics Canada, Corporation and Labour Union Return Act, 1970 Information Canada, cat. no. 61-210

It should be noted that the data in Table 2 are presented in terms of the percentage of output, not the percentage of corporate units. The majority of Canadian firms are, of course, Canadian owned. However, foreign ownership is concentrated among the larger firms, the very group that should be the mainstay of the industrial R & D and innovation. The vast majority of the 35,000 Canadian firms lack the internal capability for innovation. Only 200 have five or more graduate staff engaged in research and development. Most of the remainder are not even capable of searching for, and accepting without help, the technology available elsewhere. These weak firms tend to acquire only technology which is strongly marketed or delivered free.

The high degree of foreign ownership in Canadian industry is the result of many decades of policies which used tariffs to encourage investment in production of goods in Canada without being concerned about ownership, development of indigenous technological capability and location of R & D. By the time the importance of having a complete technological capability (as different from the production capability alone) began to be appreciated, the ownership structure favouring import of technology was solidly established. There is no intention to "disestablish" it in any way. In fact, foreign investment in Canadian industry continues to be encouraged. Nevertheless, it is clear that the sum total of decisions on R & D and technology transfer, which are made by controlling foreign interests to gain their individual objectives, will not often be likely to coincide with national needs. Complementary national policies are therefore needed to restore the balance. The relatively high level of government in-house R & D is one manifestation of such policies.

The concept of technological interdependence accepts the fact that much of Canadian industry will remain dependent on technology transfer from abroad, but it demands the development (in selected areas of specialization) of domestic excellence and complete innovative capability, by international standards. The balance will be restored when Canada becomes an exporter of technology (both "high" and "low") as well as of goods, to an extent appropriate to its place among the industrialized nations. Two principal routes are being used towards this end: stimulation of independent R & D within inudstry and enhancement of technology transfer from government laboratories.

4. SOME ROUTES FOR INTRA-NATIONAL TRANSFER

Taking for granted the knowledge of the general characteristics of technology transfer as a process, we shall review some routes utilised by the federal government to increase the Canadian content of industrial innovation in Canada by transfer of technology from federal sources. Attention will be concentrated on transfer to the secondary manufacturing industry, since federal laboratories are a potentially strong, but not fully tapped, source of technology for that industry.

There is an important qualification to this approach. We believe that if a technology needed by industry can economically be developed within industry, it should be developed right there, rather than being developed in government laboratories for the purpose of transfer. We are concerned primarily with the transfer of technology which has necessarily been developed within government laboratories to meet government's own needs. The decisions as to the extent to which these needs have to be met through intramural effort require careful scrutiny. Such scrutiny (known as the "Make or Buy" policy) is now an established policy of Canadian government. It provides for diversion of funds to industrial contracts. The amount so diverted is growing from year to year. The estimated amount for the current financial year is $121 million (ref. 12).

Arrangements for Interaction

There are three major roots which facilitate technology transfer to Canadian industry by using financial incentives, namely:

1) Procurement of equipment by mission-oriented departments.

2) Procurement of R & D by mission-oriented departments.

3) Grants (or equivalents) from technological capacity assistance programs (production or R & D).

Some of these have technology transfer as the principal objective. In many cases however, the objective of technology transfer is either secondary to that of obtaining the needed products, R & D results or expanded production capability. In many others, technolgoy trnasfer is not an objective at all, but can occur as a result of demands created within a strengthened firm. Whether transfer occurs as a direct component of the financial transaction depends very much on the degree of interaction provided for, or even built into, the agreement. For example, contracting out an R & D program on the basis of capability resident within the firm may expand the capability of that firm but is not likely to involve transfer. Contracting out the extension, or a complementary part, of an in-house R & D program is very likely to result in technology transfer. Such transfer may in fact be assured by the conditions stipulated in the contract.

The ideal vehicle is provided by integrated projects, i.e. projects in which full technical cooperation actually does take place, say by setting up a mixed working team. This has been done under complete government financing, but is also possible as a joint project, i.e. a cooperative project in which both partners contribute to the cost. In instances of great convergence of interests, cooperation may take place without contractual arrangement. On the other hand, shared costs projects in which government underwrites a part of the cost without other involvement, have no direct influence on technology trnasfer.

Line Departments

Over the years, the Department of National Defence (DND) has been the most reliable supporter of projects with high degree of technology transfer. Many of them led to commercially successful exportation by industry of the technology thus acquired. Several case stories are illustrated in the Appendix. Their common feature was the highly interactive nature of the projects. The Department of Communications, an offspring of DND, continues the tradition of such support. The activities of these two departments are, of course, not unique. The majority of financial incentive programs are administered by the Department of Industry, Trade and Commerce (ITC).

Specialised Crown Corporation

The Atomic Energy of Canada Limited (AECL) is a Crown Corporation established expressly for the purpose of developing nuclear technology in Canada, and with the objective of transfer to Canadian nuclear industry - an industry non-existent at the time when AECL was set up. The principles used by AECL to ensure successful transfer (see ref. 13) are essentially the same as those underlying our recommendations reported in the next chapter. The most outstanding feature of AECL approach is its unqualified success, as measured by the success of commercial power generating plants put in operation by Canadian nuclear industry.

Interface Organizations

The final examples in this broad overview are two organizations which do not create technology for transfer but act as specialised intermediaries: Canadian Patents and Development Ltd. (CPDL) and the Technical Information Service (TIS) of the National Research Council (NRC).

CPDL is essentially an instrument for the transfer to private firms of patented and/or licenceable technology developed incidentally to the primary mission work of government laboratories. It can also act on behalf of universities and provincial research organizations. CPDL can assist prospective licensees in obtaining support from the incentive programs operated by ITC.

TIS is directed primarily towards assisting small firms, which have few or no R & D staff (about 90% Canadian manufacturing firms). Its success is based on the broad scope of the resources available to it - the NRC laboratories and library services in the first instance, backed by the other Canadian public laboratories and the international pool of knowledge. It delivers assistance on location, from headquarters and 16 field offices, some of them managed by provincial agencies under contract.

5. RECOMMENDATIONS FOR IMPROVED TRANSFER

In the estimate of many people, the mechanisms described in the previous chapter do not adequately tap the resource of federal laboratories. The blame is placed on lack of interest on the part of both federal and industrial personnel. Other critics claim that federal laboratories just do not have much useful technology to transfer. The persistence of this criticism caused the Council to set a thorough investigation of the situation. The results have been reported in ref. 11. An analysis of those findings and policy recommendations for improvement of transfer may be found in ref. 4. Although our study investigated only the situation in Canada, there are likely to be similar situations in other countries. The findings and recommendations may therefore be of interest to this conference.

The study included in-depth analysis of the process of transfer in general and of the pre-conditions in the source and the receiver necessary to successful transfer. Most of this general analysis will be omitted in this summary paper, since it is not likely to be novel to those working in the field. The process of technology transfer was recognized as being inherently difficult, requiring simultaneous meeting of many conditions between the partners-to-be. Technology suitable for transfer was available, but necessary mechanisms were lacking. In addition to several objective impediments, purely subjective, attitudinal impediments to transfer were found to be very important. These ranged from preconceived ideas on what might (or rather might not) be available, to moral objections against making the results of publicly-supported work freely available to a profit-making organization.

Industrial Pull

It is a truism that the best way to start the chain reaction which leads to technology transfer is to create conditions where domestic innovation pays, where industry is actively looking for new technology from Canadian sources. The general climate for domestic innovation depends on many conditions and policies which are governed by considerations that have little to do with technology transfer (see ref. 2). However, some special actions can be taken. For example, medium-size firms are the most likely clients for government technology, since large firms are supplied internally or by their parents abroad and small firms lack the capability to accept technology. However, medium-size firms are at a disadvantage when bidding for government procurement contracts because they seldom have all the necessary capability. The shorter delivery time offered by large competitors eliminate the time for tooling up. If government could disseminate information about future procurement needs at the earliest possible time, medium-sized firms would have a better chance.

Orientation toward a source of technology is strongly habit-forming, but the habit of looking towards government laboratories is not common in Canadian industry. The Council urged the relevant industrial associations to impress upon their members the value of improved communications with federal laboratories, and appealed to managements in manufacturing industry to maintain frequent contacts with the laboratories at all levels.

Marketing of Technology

On the other side, the need for dynamic marketing of available technology had to be impressed on government agencies. Recommendations were made for expanding the mandate of the previously discussed interface agency, CPDL. Under the proposed expanded mandate, CPDL not only could market federal inventions, but would be provided with funds to assist in transfer of non-licensable knowledge. To this purpose CPDL would study the market for knowledge in Canada and inform the appropriate laboratories of specific requirements in industry.

Institutional and Personal Incentives

The principal reason for lack of interest in technology transfer by many federal laboratories was found to lie in the simple fact that few of them have an explicit mandate to pursue such transfer (except for groups serving primary industries or performing special service functions). This represents more than a lack of incentive, since diversion of effort from assigned priorities is seen as a risk. There are other disincentives. Some laboratory personnel believe that diversion of their effort from development of new knowledge to transfer of existing knowledge will inhibit their career prospects. Some senior personnel feel that the resulting reduction of the rate of scientific productivity of their laboratory will reduce the standing of that laboratory. There is also the difficulty of obtaining budgetary allocations for activities not explicitly covered by the mandate.

The Council recommended that these impediments be removed by nothing less than a Cabinet directive. Such a directive might state that technology transfer to industry be regarded as a high priority; that resources for this activity can be explicitly budgeted for; and that achievements in such transfer be specifically recognized as one of the criteria bearing on salary and promotions.

Movement of Personnel

The Council also recommended facilitating the movement (by secondment or migration) of government scientists to industrial laboratories and vice-versa. There are administrative impediments (e.g., restricted availability of portable pension plans) which should be removed and facilitating provisions which should be publicized and expanded. In addition to the fact that personnel moving from one sector to another are often direct carriers of technology, such movement provides the best means of improving mutual knowledge of the respective environments and development of good will.

Contracting Out

The Council recommended an expansion of the current policy of contracting out, with stress on contracts favouring close technical cooperation (as discussed in the previous chapter, e.g., joint projects). In addition, strong emphasis was placed on the need to expand the scope of contracts, so as to include system design and project management - a rare feature in current practice.

Procurement Planning

The value of early notices to industry of long range procurement planning has already been mentioned. By involving laboratories in such planning, procurement agencies would facilitate action on their part to transfer technology to industry that would be needed in the subsequent bidding. It is not infrequent that a firm cannot invest in industrialization of some technology from a government source, if the same technology is also made available to its competitors. The tendency of the laboratories to refuse favouring one firm with respect to another is understandable, but is often misplaced. The Council accepted the view that fairness has to be assessed on the basis of long range opportunities rather than for each case alone. Careful use of "chosen instruments" to assure the existence of one domestic supplier for a given need is usually in the public interest.

6. CONCLUSION

Some of the above recommendations may constitute a re-statement of the obvious to participants in this conference, yet they are not superfluous in the Canadian situation. After the publication of these findings, two seminars were held with laboratory directors and other senior personnel from government and industry. The favourable reaction of participants in these seminars to Council's assessment and proposals was reported to the Minister of State for Science and Technology. The Minister, after consultations with his colleagues, appointed a special committee of senior officers from government and industry. Its mandate was to select the most important among the Council's recommendations, to select the means by which these recommendations may be most effectively implemented and to pursue their implementation with the relevant departments of government and industrial associations. The committee was reporting directly to the Minister. Its final report has been submitted and the recommendations for further action are awaiting consideration by Cabinet.

It may be surprising to this international group that this paper deals so extensively with the means of enhancing intra-national transfer of technology. In conclusion, I wish to emphasize again that this is not due to any isolationist tendencies. The Science Council strongly supports the principle of technological interdependence through international trade in high technology products and technology transfer. It is, however, the case that Canada must correct its own technological imbalance in order to obtain a firm footing for expansion of international cooperation.

LIST OF REFERENCES

Publications of the Science Council of Canada*

Reports

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2. No. 15 - Innovation in a Cold Climate: The Dilemna of Canadian Manufacturing, October 1971 (SS22-1971/15,$0.75)

3. No. 21 - Strategies of Development for the Canadian Computer Industry, September 1973 (SS22-1973/21,$1.50)

4. No. 24 - Technology Transfer: Government Laboratories to Manufacturing Industry, December 1975 (SS22-1975/24, Canada: $1.00, other countries: $1.20)

Background Studies

5. No. 11 - Background to Invention, by Andrew H. Wilson, 1970 (SS21-1/11, $1.50)

6. No. 17 - A Survey of Canadian Activity in Transportation R & D, by C.B. Lewis, May 1971 (SS21-1/17, $0.75)

7. No. 19 - Research Councils in the Provinces: A Canadian Resource, by Andrew H. Wilson June 1971 (SS21-1/19, $1.50)

8. No. 22 - The Multinational Firm, Foreign Direct Investment, and Canadian Science Policy, by Arthur J. Cordell, December 1971 (SS21-1/22, $1.50)

9. No. 23 - Innovation and the Structure of Canadian Industry, by Pierre L. Bourgault, October 1972 (SS21-1/23, $2.50)

10. No. 32 - Technology Transfer in Construction, by A.D. Boyd and A.H. Wilson, January 1975 (SS21-1/32, $3.50)

11. No. 35 - The Role and Function of Government Laboratories and the Transfer of Technology to the Manufacturing Sector, by A.J Cordell and J.M. Gilmour, April 1976 (SS21-1/35, Canada: $6.50, other countries: $7.80)

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* The above publications (especially the Background Study No. 32) contain together a comprehensive list of relevant Canadian references. In addition, a number of reports and background studies describe the situation in particular disciplines or fields of application, as exemplified by ref. 6. A full list of Council's publications can be found in the latest Annual Report. Council's mailing address is: 150 Kent Street, Ottawa, Ontario. Canada, K1P 5P4

Other References

12. Canada, Ministry of State for Science and Technology, Federal Science Programs, 1977/78, Supply and Services Canada, 1977, cat. no. ST21-3/1978

13. Perryman, E.C.W. Technology Transfer, Atomic Energy of Canada Ltd., 1974

APPENDIX EXAMPLES OF CASE HISTORIES OF TECHNOLOGY TRANSFER

Lightweight Airborne Doppler Navigation System

This was designed and developed in the 1950s by DND to meet a military requirement for a lightweight (100 lb) self contained accurate airborne navigation system. In essence it consisted of a vacuum-tube doppler navigation system supplemented by an analog velocity-vector computer in the aircraft. With the event of reliable transistors DND redesigned the doppler radar and greatly reduced the size, weight and power consumption.

The Canadian Marconi Company (CMC) was involved in the project from the early stages. Company engineers were assigned to the Defence Research Telecommunications Establishment (now Communications Research Centre) for training in high-reliability semi conductor circuit design.

Initially, the Company investigated improvements to systems developed elsewhere. By 1956, CMC had succeeded in producing a dual antenna system, incorporating a frequency modulation technique which proved to be a major breakthrough. Acquisition of this industrial development and production expertise enabled the Company to fully exploit the technology. For over two decades CMC has developed and produced navigation models acceptable to many military and civilian agencies for both helicopters and fixed-wing aircraft.

Over 250 doppler systems have been sold by CMC for Canadian military use. In addition there have been large export sales of both vacuum-tube and transistor models. Export sales stemming from this activity now exceed 300 million dollars, and a continuing demand for this type of equipment is anticipated.

The Alouette and ISIS Satellites

A widely known product of DND's contractual associations with industry involving technology transfer is the series of Alouette and ISIS satellites. The contractual work for Canada's first satellite, Alouette I, launched on 29 September 1962, enabled many Canadian firms to get their foot in the space program door. Alouette I was built in DND's Defence Research Telecommunications Establishment (DRTE), the parts being fabricated in industry to DRTE requirements. The second satellite, Alouette II, which was launched on 29 September 1965, was also built in DRTE, but the occasion was taken to indoctrinate industry into satellite expertise; at one time as many as 80 employees of industry were working in DRTE. Canada's subsequent satellites were built by industry, with some help from the government research teams. All satellites are successful; the lessons have been well learned.

As a result of the technologies acquired through Canadian Satellite work, the two principal Canadian contractors, at that time The de Havilland Aircraft of Canada Ltd., and the RCA Victor Company of Canada Ltd., were able to develop markets for advanced space science and applications subsystems. de Havilland's Spar Division and its successor company, Spar Aerospace Products Ltd., has sold STEM devices (antennas, experimental booms, gravity gradient booms) worth several tens of millions of dollars, most of which has been exported into the U.S., and RCA Victor, which became RCA Limited, has supplied telemetry transmitters and other space subsystems for many American satellites resulting in the same order of export sales.

A domestic market for space products is developing in Canada. The ability of Canadian industry, now primarily embodied within Spar Aerospace Products Ltd., to manufacture many of these products should result in substantial savings to the Country's economy.

Cathodic Protection of Ships' Hulls

Defence Research Establishment Atlantic (DREA) physicists showed that the strength of electrical potential fields around ships' hulls were related to the amount of hull corrosion present. A study of the phenomenon led in the 1950's to the design of a system giving complete protection from corrosion to the underwater hull of a ship, with consequent saving of large sums of money in replacement of plates, etc. and marked reduction in out-of-service time. This is done (a) by use of sacrificial anodes of less noble metal than the hull such as magnesium or zinc fitted to bilge keels and near propellers or (b) by an impressed voltage between the hull and a number of steel, graphite or lead-silver anodes similarly placed, such voltage being supplied from a power source in the vessel. This makes the hull a cathode and corrosion is prevented.

Cathodic protection, however remarkable as a technique, raised its own problems. For one thing, it blew the paint off the ship's bottom. For another, it lent itself to a wide variety of means. There seemed to be insufficient reasons to dictate a choice between impressed current systems and galvanic anode systems. Choices were further confused by the variety of anodes; there were magnesium anodes, steel anodes, graphite anodes, lead-silver anodes, platinum anodes, and zinc anodes, to mention but a few. However, these problems too were resolved and a successful system eventually emerged and was marketed.

In subsequent research, DREA showed that when a ship is cathodically protected a mild alkaline environment is produced at the hull plating and hence special alkali resistant paints are required. Such paints were developed in collaboration with paint manufacturers to give a relatively even distribution of current over the hull and to have sufficiently lasting antifouling properties to enable a two-year docking period to be achieved. Vinyl paints satisfied these requirements but problems arose in getting vinyls to stick to steel when applied by shipyard labour under shipyard conditions. These problems were finally overcome by a combination of research and testing to improve the properties of the product and by improvement of the conditions of application, education of labour and supervision.

A cooperative research project with Cominco Ltd. and the Defence Research Establishment Pacific (DREP) enabled cathodic protection systems based on zinc anodes to gain a distinct edge in user acceptance. The sacrificial zinc is effective and considerably less expensive.

Cathodic protection systems based on these principles have been fitted to all vessels of the Canadian Forces, and have also been adapted by other navies and commercial steamship lines. The financial benefit to DND alone has been well in excess of $10 million over the years. Cominco Ltd. has estalbished a market for its zinc estimated at well over $100,000 per year and growing rapidly.

Mr Latker

January 27, 1977

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Mr. George M. Stadler
Assistant to the President
University Patents, Inc.
2777 Summer Street
Stamford, Connecticut 06905

Dear Mr. Stadler:

Thank you for your letter of January 19, and for the copies of your proposal dealing with the transfer into the commercial area of University-developed health-related technologies.

While this is an area of important interest to the NIH, as a Government employee, I am prohibited from commenting on the technical aspects of your proposal. If you are interested in submitting a proposal, we would be happy to see that it receives an appropriate review.

Thank you for your interest,

Sincerely,

Seymour Perry, M.D.
Special Assistant to
the Director, NIH

cc: Mr. Norman Latker ✓