THE SENATE

CANADA

PROCEEDINGS

OF

THE SPECIAL COMMITTEE

ON

SCIENCE POLICY

PHASE 1

SECOND SESSION OF

THE TWENTY-SEVENTH PARLIAMENT, 1967-1968

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97038—1

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INTRODUCTION

(PHASE 1)

"The committee has already determined the three main phases of its public hearings. Beginning today we will receive submissions from the Canada Council, the Science Council of Canada, the Medical Research Council and the Science Secretariat of the Privy Council. We will also invite wise men from Canada and abroad who have developed over the years a keen interest in scientific policy. We intend during this first phase of our inquiry to concentrate on the broad questions which must be answered as a prelude to determining the main elements of a dynamic and effective science policy. We intend also to consider the implications of scientific research activities for the long-term development of our nation and the provision of a satisfying quality of life for its citizens.

Beginning in May we will receive submissions from all the more specialized research agencies of the federal Government, such as the National Research Council, the Defence Research Board, the Economic Council, Atomic Energy of Canada, and the Research Branch of the Department of Agriculture.

The third and final phase of our hearings will start, we hope, early next fall. We will then invite representations from provincial research agencies, universities, industry, labour, agricultural and other professional associations, and also from individuals who may wish to appear before the committee. We hope that all those who are interested in this broad and vital aspect of our national policy will ask to be heard. Ultimately, of course, we will submit our report to the Senate and the Government."

Maurice Lamontagne
Chairman

(Extract from the *Proceedings of the Special Committee on Science Policy,* No. 1, March 12th, 1968, pp. 1-2.)

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MEMBERS

OF

THE SPECIAL COMMITTEE

ON

SCIENCE POLICY

The Honourable Maurice Lamontagne, *Chairman*

The Honourable Senators:

Aird	Grosart	MacKenzie
Argue	Hays	McCutcheon
Belisle	Kinnear	Phillips
Bourget	Lamontagne	Sullivan
Cameron	Lang	Thompson
Desruisseaux	Leonard	Yuzyk

(Quorum 5)

Patrick J. Savoie,
Clerk of the Committee.

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ORDERS OF REFERENCE

Extract from the Minutes of the Proceedings of the Senate, November 2nd, 1967:

"The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator Gershaw:

That a Special Committee of the Senate be appointed to consider and report upon the scientific policy of the Federal Government with the object of appraising its priorities, its budget and its efficiency in the light of the experience of other industrialized countries and of the requirements of the new scientific age and, without restricting the generality of the foregoing, to inquire into and report upon the following:

(*a*) recent trends in research and development expenditures in Canada as compared with those in other industrialized countries;

(*b*) research and development activities carried out by the Federal Government in the fields of physical, life and human sciences;

(*c*) federal assistance to research and development activities carried out by individuals, universities, industry and other groups in the three scientific fields mentioned above; and

(*d*) the broad principles, the long-term financial requirements and the structural organization of a dynamic and efficient scientific policy for Canada.

That the Committee have power to engage the services of such counsel and technical and clerical personnel as may be necessary for the purpose of the inquiry; and

That the Committee have power to send for persons, papers and records, to sit during sittings and adjournments of the Senate, and to report from time to time.

After debate,

The Honourable Senator Flynn, P.C., moved for the Honourable Senator Phillips, seconded by the Honourable Senator Choquette, that further debate on the motion be adjourned until the next sitting of the Senate.

The question being put on the motion, it was—

Resolved in the affirmative."

Extract from the Minutes of the Proceedings of the Senate, November 8th, 1967:

"Pursuant to the Order of the Day, the Senate resumed the debate on the motion of the Honourable Senator Lamontagne, P.C., seconded by the Honourable Senator Gershaw, that a Special Committee of the Senate be appointed to consider and report upon the scientific policy of the Federal Government.

After debate, and—

The question being put on the motion, it was—

Resolved in the affirmative.

With leave of the Senate,

The Honourable Senator Connolly, P.C., moved, seconded by the Honourable Senator Deschatelets, P.C.;

That the Special Committee of the Senate appointed to consider and report upon the scientific policy of the Federal Government be composed of the Honourable Senators Aird, Argue, Belisle, Bourget, Cameron, Desruisseaux, Grosart, Hayes, Kinnear, Lamontagne, Lang, Leonard, MacKenzie, McCutcheon, Phillips, Sullivan, Thompson and Yuzyk; and

That the said Committee be authorized to print such papers and evidence from day to day as may be ordered by the Committee.

After debate, and—
The question being put on the motion, it was—
Resolved in the affirmative."

J. F. MACNEILL,
Clerk of the Senate.

Extract from the Minutes of the Proceedings of the Senate, March 27, 1968:

"With leave of the Senate,

The Honourable Senator Lamontagne, P.C., moved, seconded by the Honourable Senator MacKenzie:

That the terms of reference of the Special Committee of the Senate appointed to consider and report upon the scientific policy of the Federal Government be amended: in the English language version thereof by repealing the words "scientific policy" wherever the same therein appear and substituting therefor the words "science policy"; and in the French language version thereof by repealing the words "le programme scientifique" wherever the same therein appear and substituting therefor the words "la politique scientifique".

After debate, and—
The question being put on the motion, it was—
Resolved in the affirmative.

ROBERT FORTIER,
Clerk of the Senate.

REPORTS OF THE COMMITTEE

WEDNESDAY, December 20th, 1967.

The Special Committee of the Senate on the Scientific Policy of the Federal Government makes its First Report as follows:

Your Committee recommends that its quorum be reduced to five (5) members.

All which is respectfully submitted.

MAURICE LAMONTAGNE,
Chairman.

THURSDAY, February 1st, 1968.

The Special Committee of the Senate on the Scientific Policy of the Federal Government makes its second Report as follows:

Your Committee recommends:

1. That it be empowered to adjourn from place to place; and

2. That, notwithstanding any prorogation of Parliament, the supporting staff of the Committee shall continue in the employ of the Senate upon the terms and conditions of their respective contracts and under the management and direction of the honourable senator now chairman of the Committee.

All which is respectfully submitted.

MAURICE LAMONTAGNE,
Chairman.

MINUTES OF PROCEEDINGS

TUESDAY, March 12, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 10.00 a.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Argue, Bélisle, Bourget, Desruisseaux, Grosart, Kinnear, Lang, MacKenzie, McCutcheon, Sullivan, Thompson and Yuzyk—(13).

Present but not of the Committee: The Honourable Senators Carter, Inman, Nichol and Roebuck—(4).

In attendance:

R. J. Batt, Assistant Law Clerk and Parliamentary Counsel, and Chief Clerk of Committees.

Philip Pocock, Director of Research (Physical Science).

Gilles Paquet, Director of Research (Human Science).

The following witnesses were heard:

THE CANADA COUNCIL:

J. A. Corry (Member)

Napoléon Leblanc (Member)

Jean Boucher (Director)

F. A. Milligan (Assistant Director)

At 12.55 the Committee adjourned to the call of the Chairman.

TUESDAY, March 12th, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 3.00 p.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Argue, Belisle, Bourget, Desruisseaux, Grosart, Kinnear, Lang, MacKenzie, McCutcheon, Phillips, Sullivan, Thompson and Yuzyk—(15).

Present but not of the Committee: The Honourable Senators Carter, Denis and Smith (*Kamloops*)—(3).

In attendance:

R. J. Batt, Assistant Law Clerk and Parliamentary Counsel and Chief Clerk of Committees.

Philip Pocock, Director of Research (Physical Science)

Gilles Paquet, Director of Research (Human Science)

The following witness was heard:

Dr. C. J. Mackenzie, Chancellor, Carleton University, Ottawa.

At 4.55 p.m. the Committee adjourned to the call of the Chairman.

WEDNESDAY, March 13th, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 9.45 a.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Bélisle, Bourget, Desruisseaux, Grosart, Kinnear, Lang, MacKenzie, McCutcheon, Phillips, Sullivan, Thompson and Yuzyk—(13).

Present but not of the Committee: The Honourable Senators O'Leary (*Antigonish-Guysborough*) and Pouliot—(2).

In attendance:

Philip Pocock, Director of Research (Physical Science)

Gilles Paquet, Director of Research (Human Science)

The following witnesses were heard:

THE SCIENCE COUNCIL OF CANADA:

Dr. O. M. Solandt (Chairman)

Dr. H. E. Petch (Member)

At 1.00 p.m. the Committee adjourned to the call of the Chairman.

WEDNESDAY, March 13th, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 3.00 p.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Argue, Bourget, Deschatelets, Desruisseaux, Grosart, Kinnear, Lang, MacKenzie, McCutcheon, Phillips and Thompson.—(12)

Present but not of the Committee: The Honourable Senator Denis.—(1)

In attendance:

Philip Pocock, Director of Research (Physical Science).

Gilles Paquet, Director of Research (Human Science).

The following witness was heard:

Professor V. W. Bladen, Department of Political Economy, University of Toronto.

At 5.00 p.m. the Committee adjourned to the call of the Chairman.

TUESDAY, March 19th, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 10.00 a.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Belisle, Cameron, Grosart, Hays, Kinnear, McCutcheon and Phillips. (9)

Present but not of the Committee: The Honourable Senators Blois, Carter, Irvine, Kickham, MacDonald (*Queens*), McGrand, Pouliot, Prowse and Roebuck. (9)

In attendance:

R. J. Batt, Assistant Law Clerk and Parliamentary Counsel, and Chief Clerk of the Committees; Philip Pocock, Director of Research (Physical Science); Gilles Paquet, Director of Research (Human Science).

The following witness was heard:

Professor P. M. S. Blackett, Advisor to the British Minister of Technology, and President of the Royal Society.

At 1.00 p.m. the Committee adjourned to the call of the Chairman.

WEDNESDAY, March 20th, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 2.30 p.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Belisle, Desruisseaux, Grosart, Hays, Kinnear, MacKenzie, McCutcheon and Sullivan. (10)

Present but not of the Committee: The Honourable Senators Carter, Kickham, Paterson and Quart. (4)

In attendance:

Philip Pocock, Director of Research (Physical Science)
Gilles Paquet, Director of Research (Human Science)

At approximately 3.30 p.m., the Chairman retired due to illness and the Honourable Senator MacKenzie was appointed Acting Chairman.

The following witness was heard:

Professor Arthur Porter,
Head, Department of Industrial Engineering,
Acting Director, Center of Culture and Technology,
University of Toronto.

At 4.40 p.m. the Committee adjourned to the call of the Acting Chairman.

THURSDAY, March 21st, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 10.00 a.m.

Present: The Honourable Senators MacKenzie (*Acting Chairman*), Aird, Belisle, Desruisseaux, Grosart, Hays, Kinnear, McCutcheon and Sullivan. (9)

Present but not of the Committee: The Honourable Senators Gouin, Hollett and Pouliot. (3)

In attendance:

R. J. Batt, Assistant Law Clerk and Parliamentary Counsel, and Chief Clerk of Committees.

Philip Pocock, Director of Research (Physical Science)

Gilles Paquet, Director of Research (Human Science)

In the absence of the Chairman and on motion of Senator Grosart, it was *Resolved* that Senator MacKenzie be elected Acting Chairman.

The following witnesses were heard:

THE SCIENCE SECRETARIAT OF THE PRIVY COUNCIL:

Dr. Robert Weir, Director.

G. T. McColm, Science Advisor.

Dr. Ray W. Jackson, Science Advisor.

At 12.45 p.m. the Committee adjourned to the call of the Acting Chairman.

THURSDAY, March 21st, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 3.30 p.m.

Present: The Honourable Senators MacKenzie (*Acting Chairman*), Aird, Belisle, Desruisseaux, Grosart, Hays, Kinnear, McCutcheon, Phillips and Sullivan. (10)

Present but not of the Committee: The Honourable Senators Denis, Gouin, Hollett and McGrand. (4)

In attendance:

Philip Pocock, Director of Research (Physical Science)

Gilles Paquet, Director of Research (Human Science)

The following witnesses were heard:

THE MEDICAL RESEARCH COUNCIL:

Dr. G. Malcolm Brown, Chairman.

Dr. G. M. LeClair, Member.

Dr. J. A. McCarter, Member.

At 5.10 p.m. the Committee adjourned to the call of the Acting Chairman.

WEDNESDAY, April 17th, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 10.000 a.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Argue, Belisle, Bourget, Cameron, Desruisseaux, Grosart, Hays, Kinnear, Lang, Leonard, MacKenzie, McCutcheon, Phillips (*Prince*), Sullivan, Thompson and Yuzyk. (18)

Present but not of the Committee: The Honourable Senators Blois, Denis, Fournier (*De Lanaudière*), MacDonald (*Queens*), McGrand, O'Leary (*Antigonish-Guysborough*) and Paterson. (7)

In attendance:

R. J. Batt, Assistant Law Clerk and Parliamentary Counsel and Chief Clerk of Committees.

Philip Pocock, Director of Research (Physical Science)

Gilles Paquet, Director of Research (Human Science)

The following witness was heard:

Dr. Christopher Wright, Director, Institute for the Study of Science in Human Affairs, Columbia University, New York, U.S.A.

At 12.55 p.m. the Committee adjourned to the call of the Chairman.

WEDNESDAY, April 17th, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 3.00 p.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Belisle, Bourget, Cameron, Desruisseaux, Grosart, Hays, Kinnear, Lang, Leonard, McCutcheon, Phillips (*Prince*), and Thompson. (14)

Present but not of the Committee: The Honourable Senators Carter, MacDonald (*Queens*), McGrand and Paterson. (4)

In attendance:

R. J. Batt, Assistant Law Clerk and Parliamentary Counsel and Chief Clerk of Committees.

Philip Pocock, Director of Research (Physical Science)

Gilles Paquet, Director of Research (Human Science)

The following witness was heard:

Hans Selye, M.D., Director,
Institute of Experimental Medicine and
Surgery, University of Montreal.

At 5.30 p.m. the Committee adjourned to the call of the Chairman.

THURSDAY, April 18th, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 10.00 a.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Belisle, Cameron, Desruisseaux, Grosart, Hays, Kinnear, Lang, Leonard, McCutcheon, Thompson and Yuzyk. (13)

Present but not of the Committee: The Honourable Senators Benidickson, MacDonald (*Queens*), McGrand and O'Leary (*Antigonish-Guysborough*). (4)

In attendance:

R. J. Batt, Assistant Law Clerk and Parliamentary Counsel and Chief Clerk of Committees.

Philip Pocock, Director of Research (Physical Science)

Gilles Paquet, Director of Research (Human Science)

The following witness was heard:

Dr. James Rhyne Killian, Jr., Chairman of the Corporation, Massachusetts Institute of Technology.

At 1.10 p.m. the Committee adjourned to the call of the Chairman.

THURSDAY, April 18th, 1968.

Pursuant to adjournment and notice the Special Committee on Science Policy met this day at 3.00 p.m.

Present: The Honourable Senators Lamontagne (*Chairman*), Aird, Belisle, Cameron, Desruisseaux, Grosart, Hays, Kinnear, Lang, Leonard, Phillips (*Prince*), Thompson and Yuzyk. (13)

Present but not of the Committee: The Honourable Senators Benidickson, Carter, Denis, MacDonald (*Queens*), and McGrand. (5)

In attendance:

R. J. Batt, Assistant Law Clerk and Parliamentary Counsel and Chief Clerk of Committees.

Philip Pocock, Director of Research (Physical Science)

Gilles Paquet, Director of Research (Human Science)

The following witnesses were heard:

The Honourable C. M. Drury, P.C., Minister of Industry.

THE SCIENCE COUNCIL OF CANADA:

Dr. O. M. Solandt, Chairman.

Dr. R. Gaudry, Vice-Chairman, Rector of the University of Montreal.

Dr. Gordon N. Patterson, Member, Professor of Fluid Physics and Director, Institute of Aerospace Studies, University of Toronto.

THE SCIENCE SECRETARIAT OF THE PRIVY COUNCIL:

Dr. J. R. Whitehead, Principal Science Adviser.

Henry Flynn, Science Adviser.

At 5.40 p.m. the Committee adjourned to the call of the Chairman.

WEDNESDAY, April 24th, 1968

A convocation of members of the Senate met this day at 3.00 p.m. to consider Science Policy.

Present: The Honourable Senators Grosart (*Chairman*), Aird, Desruisseaux, Kinnear, Lang, Leonard, Thompson and Yuzyk.—(8)

Also present: The Honourable Senators Carter, Fergusson and McGrand.—(3).

In attendance:

R. J. Batt, Assistant Law Clerk and Parliamentary Counsel and Chief Clerk of Committees.

Philip Pocock, Director of Research (Physical Science)
Gilles Paquet, Director of Research (Human Science)

The following witness was heard:

Dr. Richard R. Nelson, Economist, The Rand Corporation, Santa Monica, California, U.S.A.

At 5.20 p.m. the meeting adjourned to the call of the Chairman.

THURSDAY, April 25th, 1968

A convocation of members of the Senate met this day at 3.00 p.m. to consider Science Policy.

Present: The Honourable Senators Lamontagne (*Chairman*), Grosart, Kinnear, Leonard, Thompson and Yuzyk.—(6)

Also present: The Honourable Senators Carter, Connolly (*Ottawa West*) and McGrand.—(3)

In attendance:

R. J. Batt, Assistant Law Clerk and Parliamentary Counsel and Chief Clerk of Committees.

Philip Pocock, Director of Research (Physical Science)

The following witness was heard:

Dr. Alexander King, Director for Scientific Affairs, Organization for Economic Co-operation and Development, (O.E.C.D.), Paris, France.

At 5.30 p.m. the meeting adjourned to the call of the Chairman.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Tuesday, March 12, 1968

The Special Committee on Science Policy met this day at 10.00 a.m.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: Honourable senators, on this occasion of our first public meeting I believe it would be appropriate for me to put on the record some background information about the scope of our inquiry and the plan we will try to follow in respect of our public hearings.

Last November the Senate agreed to set up a special committee of 18 senators to undertake an investigation of the Canadian science policy. The motion for the setting up of the committee is as follows:

> That a Special Committee of the Senate be appointed to consider and report on the scientific policy of the federal Government with the object of appraising its priorities, its budget and its efficiency in the light of the experience of other industrialized countries and of the requirements of the new scientific age and, without restricting the generality of the foregoing, to inquire into and report upon the following:
>
> (a) recent trends in research and development expenditures in Canada as compared with those in other industrialized countries;
>
> (b) research and development activities carried out by the federal Government in the fields of physical, life and human sciences;
>
> (c) federal assistance to research and development activities carried out by individuals, universities, industry and other groups in the three scientific fields mentioned above; and
>
> (d) the broad principles, the long-term financial requirements and the structural organization of a dynamic and efficient scientific policy for Canada.

The committee has engaged the services of two research directors: Mr. Philip Pocock, a former researcher at the National Research Council, who will be mainly interested in the physical and life sciences, and Professor Gilles Paquet, an economist teaching at Carleton University, who will concentrate his work mainly in the field of the human and social sciences.

As the committee proceeds with its inquiry it intends to develop its own research program on specific topics as the necessity arises. These projects will be contracted out because the committee does not feel that it should build and develop a big staff.

The committee has already determined the three main phases of its public hearings. Beginning today we will receive submissions from the Canada Council, the Science Council of Canada, the Medical Research Council and the Science Secretariat of the Privy Council. We will also invite wise men from Canada and abroad who have developed over the years a keen interest in scientific policy. We intend during this first phase of our inquiry to concentrate on the broad questions which must be answered as a prelude to determining the main elements of a dynamic and effective science policy. We intend also to consider the implications of scientific research activities for the long-term development of our nation and the provision of a satisfying quality of life for its citizens.

Beginning in May we will receive submissions from all the more specialized research agencies of the federal Government, such as the National Research Council, the Defence Research Board, the Economic Council, Atomic Energy of Canada, and the Research Branch of the Department of Agriculture.

The third and final phase of our hearings will start, we hope, early next fall. We will then invite representations from provincial research agencies, universities, industry, labour, agricultural and other professional associations, and also from individuals who may wish to appear before the committee. We hope that all those who are interested in this broad and vital aspect of our national policy will ask to be heard. Ultimately, of course, we will submit our report to the Senate and the Government.

The committee is well aware of the difficulty and complexity of its task. We hope to get the active collaboration of all those who have a contribution to make to the improvement of the Canadian research effort. If we receive this co-operation I am convinced that we will be able to produce a good report containing sound and worthwhile proposals.

[*Translation*]

It is with great pleasure that I welcome the distinguished representatives of the Canada Council who accepted our invitation to appear before us this morning, despite the fact that the notice they received left them very little time to get prepared. In any case, if the Council wants to come back at a later date, they will be most welcome to do so.

The Chairman of the Canada Council Mr. Jean Martineau, should have presented the report himself but unfortunately, this morning at the very last minute, he was detained at the Supreme Court of Canada where he is defending some clients. He apologizes for not being here this morning.

Among the delegates we have with us this morning, first of all, I would like to introduce Mr. Napoleon Leblanc on my right, vice rector of Laval University, and Dr. Corry, whom, I am sure several of you will recognize. He is a former principal of Queens University; Mr. Jean Boucher who is Director of the Canada Council, and finally, Mr. Milligan who is an Assistant Director of the same Council.

[*English*]

We received only yesterday the introductory statement that the Council wants to submit to us and since this submission is rather short, I would propose, if you have no objection, to ask a representative of the Council to read this statement before we go into any discussion. After all, it is only about five and a half pages. Would the committee agree to this procedure?

Hon. Senators: Agreed.

[*Translation*]

The Chairman: Mr. Napoléon Leblanc will first of all speak on behalf of the Canada Council.

MR. NAPOLEON LEBLANC, VICE-RECTOR, LAVAL UNIVERSITY AND MEMBER OF THE CANADA COUNCIL: Mr. Chairman, members of the Committee, on behalf of the Canada Council I would like to express the Council's satisfaction for having this opportunity to speak of the needs of research in the social sciences and the humanities. May I say that, like our chairman this morning, we shall be speaking on behalf of our clients.

The Council views the activities of your Committee with great pleasure, because we believe that the development of Canada in its present situation as a country and as a partner in the international community requires that we concern ourselves with providing adequate information to the public if we want the public to share in the important decisions which will have to be considered over the next few years, and if we are to have available the scientific equipment necessary to insure the harmonious development of our society. I am referring here not only to those technological improvements that we shall have to provide, but also to new developments which will enable us to improve understanding between the various groups and interests that affect our daily life.

The Canada Council, on the basis of an experience which is still relatively short but which has already proved highly rewarding, is submitting to you an introductory statement of the situation as it now stands and particularly of the needs it expects to be faced with.

Thank you, Mr. Chairman, for welcoming us this morning. We are at your disposal to answer any questions arising from the Council's introductory statement.

[*English*]

Mr. JEAN BOUCHER, DIRECTOR, CANADA COUNCIL: Mr. Chairman, do you want the brief read in English?

The Chairman: Yes, in English.

Mr. Boucher: Then, Mr. Chairman, I will just read the statement in English. The statement is divided into three broad sections, one of which deals with broad trends, another with the programmes of the Canada Council, and finally a brief section on science policy. The statement is as follows:

1. Broad Trends: From the nineteen twenties on, it became each year more apparent to governments and other policy-making bodies that they needed to invest in the search for more adequate knowledge if they were to understand, control and use to best advantage the forces of industrialization, urbanization and communication. This evidence has suddenly become even more glaring with the launching of our world on an accelerated pace of scientific and technological advance which shows no prospect of reversal and clearly brings in its wake an equally sweeping pace of social, economic and political change.

2. Research as the means of deciphering and extending our control over the environment, physical and human, thus becomes a dominant concern and vital activity of the post-industrial society. The task is such that it needs to be attended to at the highest level of political organization. National governments have therefore been led to assume the major responsibility for building up and maintaining such activity. They are now attempting to give this type of creative investment an appropriate weight in the pursuit of other national objectives and in the programming of public expenditures.

3. Whatever difficulty there is in reaching comprehensive estimates of the financial returns of a science policy, such a policy broadly rests upon the necessity of enlarging knowledge as the only way to ensure the ability of nations to deal with problems of growing complexity and to increase social and economic performance in a revolutionary age, "to see better where we are and whither we are tending". It also rests upon the obligation for any advanced society to make full use of its creative talents and to foster the advance of knowledge itself as a fundamental purpose of human life.

4. It is mainly for the social sciences and humanities to provide adequate interpretations of the new forces at play and a manageable range of options for man and society in a world where all traditional patterns are being challenged. Yet it is only recently that this vital role has been recognized. Now a race against the clock is on.

5. It is generally recognized in Canada that, although we benefit from research done abroad, we must put research on the national agenda for the following reasons:

—we could not otherwise use our most creative human resources,

—our educational institutions could not attract and retain first rate personnel,

—the country could not hold its rank among technologically advanced nations and have its say in undertakings which are now shaping the world,

—some Canadian problems require Canadian solutions,

—Canada is an exceptionally promising place for the investigation of certain research problems of world-wide significance.

6. Over the past twenty-five years and more particularly over the past twelve, investment in research has become a major objective of governments and other decision-making bodies in industrialized nations. The U.S. Government which is now spending $16.5 billion on research and development (R.&D.), was spending less than $100 million in 1940. In Canada, very substantial increases have been allotted to research budgets in recent years. Still, the country will have at least to double its effort in a few years if it is to catch up with OECD countries with no higher standard of living, who spend between 2 and 3 per cent of their GNP on R.&D.

7. One of the most recent trends of significance has been the growing importance of the social sciences in the pattern of government research support. In the U.S., the social sciences research budget of the federal government, although still comparatively modest, has been increasing 30% faster annually than those of the physical and life sciences taken together. Over the past four years in Canada, from 1964-65 to 1968-69, while the NRC-MRC budgets have not quite quadrupled (from $26 to $93 million) the Canada Council budget for the social sciences and humanities has grown twelve fold (from $1.4 to $17.2 million). That budget is still, however, less than one-fifth of the combined budgets of the other two Councils; indeed it is only two-thirds the increase granted these two Councils for the year 1968-69. Yet social scientists and humanists outnumber natural scientists in the faculties of Canadian universities.

8. In any comparison of the budget growth of the three Councils, another important fac-

tor has to be borne in mind. It is the fact that the Canada Council does not finance its programmes exclusively from annual parliamentary appropriations but also from the income yielded by its endowment funds, statutory and privately bequeathed. Two consequences follow from this special financial position. On the one hand, Parliament does not have to provide, from year to year, all the moneys required for the research aid programme in the social sciences and humanities, as it has to do in the natural sciences. On the other hand, whatever the relativity adopted between the three Councils, the Canada Council will always require a somewhat larger percentage increase in its annual parliamentary grant than the percentage increase envisaged for its programme, since its other sources of revenue are relatively constant.

The Canada Council's Programmes:

9. By statute, the Canada Council bears responsibility for providing national support to free research in the social sciences and humanities. It deals with research, not with development. Its assistance goes to applied as well as to fundamental research. However, it does not support contractual research, but only freely initiated projects.

10. The Canada Council and NRC have instituted effective arrangements to look after applications which might otherwise fall between two stools in frontier disciplines such as psychology, archaeology, anthropology, geography—and, I might add, mathematics. There is a sharing of responsibility for certain undertakings bringing together scholars from various disciplines. With the growing interest in such interdisciplinary research, this collaboration should become ever closer.

11. Doctoral fellowships: In the field of research training, the Council concentrates its efforts at the pre-doctoral level. Next year, with close to $10 million for an expected 2,350 awards, the Council hopes to be only two or three years away from reaching adequate coverage of the doctoral population in the social sciences and humanities. Apart from Canadian students at home, the programme extends to foreign students in Canada who hold permanent residence visas, and to Canadian students abroad. These three categories should total 5,650 full-time students next academic year, compared with some 4,750 in the physical and biological sciences.

12. At present, only some 37 per cent of the teaching staff of Canadian universities in the social sciences and humanities are in possession of their doctoral degrees, while the percentage is over 50 in the natural sciences. Besides, the former usually take two more years than the latter to complete their doctoral programmes. To attract the more exceptional students into the competition, to keep at their thesis work those who have completed their residence requirements, and to bring back to their doctoral work those who have traded it for teaching or research posts, the Council has raised the value of its fellowships and extended their length of tenure to a point fully competitive with the most attractive foreign schemes.

13. As the average repatriation rate of Canada Council fellowship holders is of the order of 80 per cent, there would seem to be no good reason for the Council to change its traditional policy of extending support to the large number of its fellows who choose to study abroad, as the best way of maintaining their ties with Canada. In any instance, awards for study in Canada have grown from 127 last year to 329 this year and are expected to number 624 in 1968-69. While a year ago the U.S. contingent represented 38 per cent of all award winners and the Canadian one only 30 per cent, the situation is fully reversed for next year, with figures standing at 28 per cent for the U.S. contingent and 40 per cent for the Canadian contingent.

14. Research projects. With over $3 million for research grants and senior fellowships, the Council is able this year to assist some 7 per cent of the 10,600 university teachers in the social sciences and humanities, a larger community than that for which the NRC and MRC are jointly responsible. It hopes to spend some $4.5 million next year in this area. There is no evidence that the emerging techniques of research in the social sciences and humanities are less expensive than those used in most branches of the natural sciences, and much of the work of both sides can still be accomplished with modest means. The Council will not be in a position to assess the limits of its present contribution or to forecast its future responsibilities until adequate information is available on the level and coverage of support coming from other sources, private or public, contractual or free, Canadian or foreign. The Council was about to launch such a survey a

year ago, when it decided to join forces with the Science Council on a broader review of the funding of university research (the Macdonald Survey). It is doubtful, however, that the resulting survey will provide all the answers that the Council needs in order to plan its programme. It should tell us more about such things as the sharing of responsibilities for computer expenses in research budgets. It should also comment on the necessity for Canadian universities or foundations to adopt the American practice of attaching a separate stipend to grants for free research in order to make this activity more competitive with research contracts offered by public and private agencies only too willing to make research economically attractive. This latter problem, although by no means extending to all the disciplines, is particularly acute in some of the social sciences and may prove to be critical in the development of free research in Canada. The position of the Council is further complicated by the fact that government departments with social sciences research budgets can feel free at times to provide stipends with research grants or to shift applications to their research contracts programmes. Some pragmatic solution will have to be found if only to remove the penalty which now inhibits the initiative of the more widely sought career researchers.

15. The adjudication system of the Council for research grants applications rests not only upon final review by an academic panel, but also upon assessment by specialists of each research area proposed. This is a particularly elaborate system involving almost three times as many assessors as applicants. In order to bring to bear the best standards of international scholarship, the Council is turning for help to experts abroad almost as much as to experts at home. A welcome by-product of such a system is the quality of comments produced and passed on to applicants with a view to improving their performance. The Council attaches great significance to its ability to maintain the system in the face of a rapid growth in applications.

16. Research communication: With similar objectives in mind, the Council is at present trying to improve research information and communication

—by pressing for the establishment of a continuing national inventory of research activity in the social sciences and humanities;

—by sponsoring a study of deficiency in research supporting services, such as storage and retrieval of social and economic data;

—by assisting learned societies in the launching and maintenance of learned journals of international caliber; and

—by encouraging, apart from the large annual meetings of learned societies, the holding of ad hoc meetings of specialists in key research areas where effective national or international co-ordination can be achieved.

17. The Council is giving encouragement to the strengthening of learned societies so that they could effectively service the scholarly community and co-ordinate its research efforts. It is firmly convinced that scholars themselves must participate actively in the development of research policies. These policies must be expressed through learned societies equipped to review periodically the substantive progress made in various research areas and to deal with gaps and duplications.

18. Research equipment: The Council has not had to provide for the installation of computers in Canadian universities as the NRC has done. The development of computer services now calls for a review of the NRC and Canada Council policies and this will have to be completed in the near future. As to other mechanical equipment required for the conduct of research in the social sciences and the humanities they can generally be provided through the present system of research grants offered by the Council.

19. However, the major issue related to the adequate tooling of social and humanities research in Canada is undeniably that of the present state of our university library collections. This is the fundamental and most dramatic shortcoming of Canadian research institutions especially when compared with American ones. Not only is Canada sadly lagging behind the United States in this respect but there are good reasons to believe that this gap is broadening every day. The situation is such that while Canada can now offer research expenses to its scholars, it can seldom ensure ready access to essential research material. This problem was raised by the Bladen Commission who suggested that the Canada Council should at least be able to make a token contribution of some \$2 million every year towards the building up of research collections. Unfortunately the Council is still unable to provide more than \$1

million a year for this purpose, while the NRC and MRC are able to devote some $12 million to the tooling of university research facilities in their own fields. However, the Council has sponsored, through the AUCC,* a survey of library resources which has now been completed. The Downs Report published later this month deals in part with the prospect of compensating for the paucity of research materials by a more systematic exploitation of the new technological devices which are now in the process of development. Now that this report is available, it is hoped that a general attack on the problem will become possible. If Canada does not want its universities to slip quickly by international standards to the level of glorified high schools, it will have to double its university library collections and resort to extensive use of all proven technological facilities. This will call for real co-operation and self-discipline among universities, and for quite substantial expenditures by governments. It is easily a $200 million operation.

20. Research overheads: While the Bladen Commission made specific recommendations as to the advisability for the federal government to include an allowance for a 30% overhead in its research grants to cover the very substantial costs incurred by universities in accommodating research activities, this matter has not yet been resolved. In part, it has been met indirectly by the new federal system of operational support for post-secondary education, but it has not been the object of any specific policy decision. The Council has been keeping an open mind on this matter and would be prepared to pursue discussions with other interested parties. It is inclined to believe, however, that such discussions might now profitably extend to other more specific related problems such as computers and stipends.

A Science Policy for Canada

21. The Canada Council believes that a science policy has to take account of two major objectives:

a) It must plan for a sustained allocation of financial resources, for both development and research, which would enable Canada to move towards international standards of public expenditures in this field and allow for a gradual bridging of the gap between the human and the physical sciences.

b) It must provide a rationale for the apportionment of government funds between ministries and research councils on the one hand, and on the other, between development budgets, research contract budgets and research grants budgets, without placing undue emphasis in the research grants budgets on the largely illusory distinction between pure and applied science.

22. The Council believes that the only enforceable system of priorities for the research community is one that is self-imposed. An obvious prerequisite would be a comprehensive appraisal by the community itself of its own achievements and inadequacies with a view to determining which research programmes must continue to compete with one another for limited funds and which ones should be guaranteed priority treatment for reasons of scientific as well as social urgency.

23. The Council believes that the exact pattern of administrative organization that would be best suited to discharge such a policy will evolve naturally from discussions that would bear on the fundamental objectives to be pursued.

Thank you, Mr. Chairman.

[*Translation*]

Senator Bourget: Mr. Chairman, would it be possible for us to have a translation of this document, because it contains several technical terms which are difficult to understand?

The Chairman: Yes. Thank you, Mr. Boucher.

[*English*]

Perhaps Dr. Corry would like to add something at this stage.

Dr. J. A. CORRY, MEMBER, CANADA COUNCIL: Mr. Chairman and honourable senators, at the outset I want to apologize for coming in late. This was not due to any discourtesy but simply to the difficulties of planning how one gets here in time if one drives. As to what I should like to say now beyond what is in the brief, I think it is very little. What may be worth noting, however, it seems to me, is the urgency of the Canada Council's worries as to whether we have enough resources for doctoral fellow-

* Association of Universities and Colleges of Canada.

ships and for supporting research projects in the social sciences and the humanities. To put it very simply, and not quite in the same words as are used in this brief, it is very clear that all the western societies, of which we are one, are continuously pouring greater and greater resources into scientific research. The pace of scientific discovery on the pure scientific side is very fast. The rate at which these scientific discoveries are then applied to human life and society is accelerating all the time and we are faced with social and economic change—and I would add consequent disruption, because the two are intertwined—which is progressing at a rate never before known, I think, by any human society.

Now, bearing that in mind, the urgency of the Canada Council's needs is this: that unless we can keep somewhat in pace in the study of social and economic and other aspects of our society, we are going to be overrun by the rate of physical and scientific change and our society's disruption by it. Therefore it seems to me that the need is getting more and more pressing all the time for us, first, to have support for young people who want to go on to deeper and more profound studies in the social sciences and humanities so that they in turn as teachers or workers in other areas can, in fact, tell more and more of us what kind of things we are involved in and where they are taking us, and, second, to have more and more resources for research in the social sciences and humanities.

To take only one instance, we see what pure scientific research is doing to us in the way of producing urban agglomerations which are likely to become totally unmanageable unless we study all the social implications of these and how to cope with them and even, I would say, how to try to prevent their getting any bigger than they must be.

This is the basis, it seems to me, of the case put forward by the Canada Council in these fields, as I understand it. That is all I would like to say just now.

The Chairman: Thank you very much, Dr. Corry. The meeting is now open for discussion and questions. To start with I will invite Senator MacKenzie to open up the discussion, since he is a former member of the Canada Council.

Senator MacKenzie: Mr. Chairman, I am very happy to have this opportunity of meeting with the representatives of the Canada Council and discussing with you and fellow members of the Senate what is a very important problem and a very important matter in terms of the life of Canadians and in the life of human beings generally. I know that our terms of reference are directed to research, but before going into that I would like to suggest to you that we are involved here with what might be described as the questions of the philosophy which lies behind the work of this Council. I am speaking of the humanities in particular and the fine arts that do not lend themselves to the kind of detailed technical research, and I am using "technical" in its specific sense, that the physical and life sciences do. For me the humanities and the social sciences are concerned with human beings, with human behaviour and the organization of human society. Dr. Corry made mention a moment ago of the results of science and scientific research in the physical and life sciences on human life and on human society. And I am not at all sure that granted the accuracy of that statement that the best mehod of coping with it is to follow almost exactly and identically in the footsteps of the scientists. I have in mind that scientific research, which has, as far as I can judge, been copied almost identically and exactly by the social scientists and those in the humanities, is an inheritance from the Germans. It was not at all a part of the philosophy of Britain or the United Kingdom and it was only to a lesser degree, as far as I know, part of the philosophy of France. It was true of Germany back in the 1880s and later. It was copied by the Americans and the emphasis upon the Ph. D. I think, can be directly attributed to its origins in Germany and in the United States. Now for the sciences, and here again I am using physical and life sciences, I think a good case can be made for the Ph. D. requirement in that area; but I wish that those in the universities in particular who are concerned with humanities and the social sciences would take a hard look at the whole philosophy of their fields of interest and work, because as I understand it, it is our concern to see what can be done about the lives of human beings which are being so directly and greatly influenced and affected by work in the natural and physical sciences.

Coming to a few questions—and some of them will be familiar to those who have been on the Canada Council or have worked with it, because I have raised them before as a member of that body—the Royal Commission which was responsible for recommending that the Canada Council be established specifically included in its recommendations that law should be on a par with the other disciplines.

I would be grateful if the director, in due course, would provide this committee with information as to what assistance has been given to the general field of law and jurisprudence, and to scholarships, fellowships and the like, in law.

I indicate or suggest that, not only because it was in the original terms of reference, but because law—and I am speaking as a prejudiced person—is the oldest of the social sciences, with possibly one exception, and it is of major importance. The very fact that the first chairman, Brooke Claxton, was a very distinguished lawyer, and the present chairman—who cannot be here this morning, because he is practising his profession—is a lawyer, is some evidence of the part or role that law has played. I do not think the Canada Council, as far as I know, has concerned itself enough with this very important area of the social sciences.

Another matter which was not, I think, specifically mentioned in the Royal Commission report is what is generally called education. And by "education," I mean here the preparation of the men and women to go into our schools, at the primary and secondary levels, to teach our children. Many of the major problems of our society arise in that area of activity, and I think it does not make sense to disregard and ignore that whole important sector and those responsible for the development of our boys and girls who become the young men and women and will in due course be confronted by the problems of our society.

So, I would like to ask the Director of the Canada Council to provide this committee with some information as to how much money is provided in this general area of education, and how many scholarships and fellowships have been awarded by it.

This was specifically brought to my mind a week ago Friday when I was giving a paper before the Saskatchewan School Trustees' Association in a very interesting and important conference week in Saskatoon, "an invitation conference", to which many distinguished people from all across Canada, from coast to coast, were invited and were present. After I finished my paper, one of the audience got up and asked me why it was that the Canada Council refused requests to assist the men and women in this most important field of education and activity.

Then, I have noticed that in the last few years there has been a fundamental change in the scholarship policy of the Council. Formerly, grants were made at the M.A. level as well as at the Ph.D. level—that is, to those preparing for further graduate work.

I know all that needs to be known about the limited funds available, but I have always maintained that the most important thing for those of us in this area of interest is to get good young men and women started; and then, if you can get them started, you can usually be sure that the best of them will keep on. The period between the completion of undergraduate work and the beginning of graduate work is, for many of them, the critical period. It is a period when many of them can go off to employment, and will not be interested in the completion of graduate studies. I think the abandonment of that program has resulted, and will result, in the loss of many able young men and women who, as I say, without any particular encouragement, will go into business, industry or somewhere else.

One or two specific questions—I will be grateful for a small memo on Stanley House. For the benefit of my colleagues in the Senate who may not know what I am talking about, Stanley House was the summer residence of a former Governor General of Canada on the south shore of the Gaspé Peninsula. It came into the hands of an American owner, I believe, and she, in her will, left it to the Canada Council, if the Canada Council were willing to accept it. The Canada Council has accepted it and makes some use of it during the summer months for the meetings of small groups of men and women in specialized fields.

I think, Mr. Chairman, it might be in order, later this summer, in July or August, if it can be arranged, for you to find out whether this committee, or such members of it as could attend, could go for a week or ten days of sessions together. I have not been there myself. I have been invited on several occasions as a member of the Council, but could not manage it. It does suggest itself to me as being one of the places where there would be no distractions—other than perhaps fishing for salmon where the members of this committee could meet together.

I notice too a reference to the Killam estate, but no details are given respecting that. I know a little about that. I would be interested to know what capital the Canada Council expects to get from that estate, and the directions of the benefactor and the executors of the estate in respect of its use.

To that I would like to add a question as to how much money, in the form of endowments or other revenue, the Council has received from private individuals and corporations. I know it does get some for specific purposes, or is asked to administer the grants of certain monies for certain specific purposes.

I was very happy to listen to the Director set out the needs of the libraries of the universities of Canada. I am one of those who believe that libraries—perhaps next to the students, and the faculty form the most important part of the university. I think if this committee could be provided with copies of the Downs Report when it is published we might be in a better position then to give our support to the recommendations in respect of libraries.

I was interested in a comment in the report that it takes longer, apparently, to produce a Ph.D. in the humanities than it does in the physical and life sciences. I think that that is statistically a fact. I am not sure that it is necessary, and I am not sure that it is wise, and, again, I am not at all sure that it is good for a lot of bright young men and women in the humanities and in the overlapping areas of the fine arts to be required, because of what amounts to a "trade union" or "system" demand, to pursue studies to the Ph.D. level.

I say this because Ph.D. work, while it can be valuable and important for those in the sciences—and I would include here certain of the social sciences—could be frustrating and could do damage to the more artistic elements in the Humanities.

I remember some eight or ten years ago when the trustees of the Carnegie Endowment for the Advancement of Teaching, composed in the main of the heads of the most important universities in the United States had a two-day discussion on this matter. There was general agreement among them, I think, with what I have said, both about the length of time that was taken, which they felt was wrong, and about the question of whether it was necessary and good for everybody to follow that course.

I am delighted that the Government of Canada has seen fit to provide the Canada Council with more money than it received from the original endowment fund. The amount of money it received was dependent upon interest rates, and it was plus or minus $3 million a year. This was more or less equally divided between the liberal arts, the humanities, the social sciences, and the fine arts, and so on. As I say, I am delighted that the Government has seen fit—and I think it is on an annual basis—to supplement that income substantially.

I agree completely with the statements that the Canada Council, and the work that the Canada Council is responsible for, does not receive either proportionately or actually nearly enough money from federal Government sources, but I would hope, I say, that in the expenditure of these moneys, though it is not our particular problem—the members of this committee are concerned with science and research—that the Council itself would keep in mind its concern, because it should be its concern, for the shape of Society and the lives of the human beings in it, which, in my opinion at least, is something very different from research in the physical and so-called life sciences.

I could go on because I have a very special interest in the work of this Council, but I know there are many others of my colleagues here—both members of the committee, and other members of the Senate, who have been good enough to attend—who would like to ask questions. I will leave any further comments that I have for later on.

The Chairman: Thank you very much, Senator MacKenzie. I wonder if Mr. Boucher would want to make some comments on the specific issues that have been raised about law and encouragement to education?

Mr. Boucher: I think I should reassure Senator MacKenzie right away with regard to law. From the outset, when the additional funds became available, it was quite clearly indicated to all our friends in law schools that law was very much included in any of our programs. Actually, the last press release regarding our research grants lists, as the major grant in the series of decisions, a grant of some $47,000 to the law school of Queen's University to compile an analytical catalogue of Commonwealth treaties. So, law is very much included. I understand that there will be 17 doctoral fellowships given in law this year.

Senator MacKenzie: You say "doctoral fellowships." The normal training of lawyers in the English or common law system is an undergraduate degree in arts followed by three years in law which, by and large, is equivalent in time, I would think, to the obtaining of a Ph.D. in the sciences, and you are expecting on top of that further studies.

Mr. Boucher: Well, I would say this, that it does happen that law students pursue studies beyond the profession certification.

Senator MacKenzie: Do they do any Ph.D. work, or is it in specialized fields?

Mr. Boucher: Doctoral studies in law—they are engaged in a doctoral program of study.

Senator MacKenzie: Their degrees in the main would be Doctor of Civil Law, Doctor of Jurisprudence, and the like?

Mr. Boucher: Yes.

Senator MacKenzie: So you, I gather, expect in the case of the law students that they would have completed both their undergraduate work in arts and their three years, which is more or less the equivalent of the Ph.D.?

Mr. Boucher: Yes, quite.

Senator MacKenzie: I may be wrong, but is there a lawyer, if I may use that term, on your academic committee?

Mr. Boucher: On our academic committee?

Senator MacKenzie: Yes.

Mr. Boucher: I have training in law, but that does not really answer your question.

Senator MacKenzie: Well, you are, and the chairman, is, I know, but I was looking through the names here, and...

Mr. Boucher: There may be some of our political scientists who have had full training in law.

Senator MacKenzie: I am a little sensitive about this issue, as Dr. Corry well knows. In other words, I am not sure that it is good enough to have a social scientist who happens to have had some training in law to protect, as it were, the special interests of the specialized group.

Dr. Corry: It depends upon the circles in which I am moving, but I still try to pass myself off as a lawyer when the occasion offers. Whether Senator MacKenzie would accept this I cannot, of course, say, but I am on the academic committee.

Senator Thompson: I do not know whether I am following this, but I am looking at my previous boss and my previous principal, and I know you did not take your Ph.D., Dr. Corry. I am trying to understand why Senator MacKenzie raised this question on the discipline of getting a Ph.D. It is, as he said, a trade union ticket in the humanities. Why are you focussing your attention, in awarding your grants, on Ph.D. recipients?

Mr. Boucher: I will try to answer this, and I hope my answer will not appear overly cute or sophisticated. I think we have to start with the fact that while the Council has more funds, it still has limited funds. When it started moving into more ambitious programs it had to do one thing. It could no longer afford to run several programs, where it could make a number of decisions dealing with a few applications but never covering any single field.

This was the situation three or four years ago, that the Council had not enough money to really cover any area. It was moving towards a situation where it could have enough money to cover certain fields, that is to stand ready to take in any good applications coming from that field.

With regard to student aid, we had to decide whether we were in the field of student aid or whether we were in the field of research aid. It appeared to us to make some sense that if we were to look after those students who are in the ultimate stage of their training as career research people or as career scholars, then we could still say that we were really dealing with researchers in training. We therefore took the ultimate degree and started counting support from the last year when they get their degree, and we are now helping students who are two years away from completing their residence in the acquisition of the top degree.

It also happens that this channel of training is still very largely regarded by our universities as the normal channel leading to the practise of the profession of teacher or scholar. We are not passing judgment on whether it is the best formula. We all know that people have very serious reservations about the actual significance of the doctoral program. We know that those programs are now being subjected to a number of modifications and improvements. We are not interested in knowing whether people have got their M.A.s. We will take people who are registered in a doctoral program whether or not they have acquired their M.A.

By the way, our M.A. scholarships were never very substantial in number. The year before I came to the Canada Council there had been none, and the year before that I think there had been 39. Today the M.A. population would be at least three times the Ph.D. population. The Ph.D. population is moving beyond 5,000. I think we can make a significant contribution to the training of that universe. I think that to deal with the M.A. population would be, certainly at the moment, beyond our means except if we maintained certain programs which would reach only a few candidates in that vast universe.

There is also the problem arising from the gradual moving of provincial governments into university student support. Not all provinces but some of the major ones now have programs of support for undergraduate students and M.A. students on the basis of competition, and it is not at all clear that it would be useful to run competing competitions for the same universe. However, we have the feeling that it makes more sense to look after a group of students, really in some way relieving the provinces of the necessity to look after them.

Senator MacKenzie: This does not apply to some of the provinces who need it most, however.

Mr. Boucher: Then the problem, of course, is whether we could have scholarship programs for certain provinces and not for others.

Senator MacKenzie: We could have general one which might not be used by some provinces but would be very useful to others.

The Chairman: I think there is another element which has not been mentioned. In the last few years the federal student loans came into operation.

Senator MacKenzie: They help very greatly.

The Chairman: I am sure that it helps to cope with the situation before the M.A. level.

Senator MacKenzie: It ends before the M.A. level as a rule so that the M.A. lad is left without either the loan or the grant. However, I have raised the point, sir, and I really need not pursue it further. What about education, if I might press you on that, Mr. Boucher?

Mr. Boucher: On education, of course, we have held on to our reservations until quite recently, not because it was constitutionally a provincial responsibility but simply because it represented again a very substantial additional population to the pool of applicants.

Senator MacKenzie: But they are important, you would agree?

Mr. Boucher: Yes. Also, because we were not quite certain that it was exclusively the responsibility of the Canada Council with no responsibility being shouldered by N.R.C., if it had to be defined exclusively as a social field and we would have had to support, for example, students who would want to study the pedagogy of botany or something like that. We could not see very much logic in our being led to this . .

Senator MacKenzie: But you could make your own distinctions?

Mr. Boucher: Yes. Also, we were not knowledgeable enough in the staff and among our advisors to sort out what would be strictly professional training and what would be really scientific or scholarly work. A good many of the projects presented to us appeared to deal with the sort of questions that a department of education in a government would be asking itself more than with questions scholars could be asking.

Senator MacKenzie: Oh, I grant you that you can make many excuses for not doing things if you do not want to do them. I am not blaming you, because this is true. But I was a member of the Council, too, sir. I think it is a mistaken policy, so I think we can rest it at that.

Mr. Boucher: Perhaps I should add that we are now relaxing the program gradually and we will consider applications from departments of education in Canadian universities.

Senator MacKenzie: Mr. Chairman, would it be in order to suggest that perhaps the Canadian Teachers' Federation or the Canadian Association of Education might present us with a brief later on?

The Chairman: At a later stage, of course, we could invite them.

Senator MacKenzie: I suggest this because I know it is a matter that is very keenly felt in that area.

The Chairman: They can certainly ask to be heard.

Senator MacKenzie: I think it would be very useful to give them a chance to explain their feelings, and also what they believe the facts to be.

Senator Thompson: Following on that, referring to libraries and looking at the view taken by the Downs Report, have you done any background work on these assessments of metro areas in considering library facilities? Have you focussed attention on libraries?

Mr. Boucher: The Downs Report?

Senator Thompson: Yes.

Mr. Boucher: The Downs Report deals primarily and esentially with university collections. It includes some reference to other facilities available in major metropolitan areas, but in a rather summary way. It deals mostly with the shortcomings of university libraries, but it takes into consideration the overall resources of large centres such as Toronto and Montreal.

Senator Thompson: I was thinking of an assessment. First of all, do we know the situation across Canada concerning university libraries, libraries in metro areas and schools? Are we aware of the need? If so, what resources can be developed to remedy this? We have had some study, for example, in Ontario on libraries in schools. We have had the Downs Report, and a previous criticism of the situation in metro Toronto. Does the Council feel any particular responsibility or give any encouragement to developing resources in this area?

Mr. Boucher: The answer to that would be no, the Canada Council does not assume that it carries any responsibility for developing public libraries. The Council has to redefine its own understanding of its mandate all the time. It usually never says a project is outside its mandate, because its mandate is so broad that if provided with additional resources, the Council could do any number of things which it is not doing presently. But the answer generally is that our present policies, our present resources, do not place us in a position to be of any assistance in the field of public libraries or in the field of undergraduate aid.

Senator MacKenzie: The Canadian Libraries Association and those affiliated with that body are seeking funds at the moment to undertake, for the whole of Canada, the kind of study of library resources which was done in the Downs Report on University Resources.

To date, they have not got that money. Until they do, or somebody does, this job will not be done. It is a very important question which my colleague has raised.

Senator Grosart: We seem to be proceeding on the assumption that the Canada Council has what might broadly be described as a grants policy. Around the country one hears very often a statement that if the Council has such a policy it is very well hidden.

Mr. Boucher said a moment ago, for example, in speaking of the educational field, that the Council was relaxing its policy. I wonder to what extent this is communicated to those people who are to benefit from this beneficent relaxation. I have heard it said, for example, that the Council, in its grants policy, has pursued what appears on the surface to be a very unscientific method of determining who shall be the beneficiaries—that is, they wait for people to apply. I do not know whether this is true.

I would assume that a council with a scientific background, a scientific outlook and, presumably, scientific procedures, would survey the whole field and decide which projects and which persons can be assisted most suitably by Canadian Council grants.

Could we have an explanation, therefore, of the relationship of the application to the decisions of the Council? What is done—when the Council decides, in its wisdom, to increase the area of its grants—to communicate with those who might come under the new policy?

MR. F. A. MILLIGAN, ASSISTANT DIRECTOR, CANADA COUNCIL: There is a problem of communication which we have encountered over the past year, particularly during my own limited experience with the Council. It might be worth recalling, as Senator MacKenzie has brought out, that for the first eight years of its life the Council lived on a very modest income from endowments. This income limited it to a program of about $1½ million, for the social sciences. This meant that the Council could not advertise its program widely. It also meant that the Council could only be highly selective in what it supported. An image of the Council in Canada developed in the universities during this period.

We have had an uphill battle over the past year in getting across to the scholars of the country the fact that the Council has funds now and is prepared to receive applications relating to any research project in the humanities or social sciences; that the chances of success are considerably greater now than they used to be; and that we are trying to offer a comprehensive program.

It is only in the past eight months that we have been developing a staff to the point where we have been able to send people to the universities to explain our policy. We found that there were many misconceptions and misunderstandings of our aims. We have been clearing up such misconceptions.

Furthermore, we have found that simply sending printed explanations to the universities, as has been done, does not solve the problem of communication. Such written statements are not read. It seems to me that the only way to cure this is by the process of visiting universities, talking to scholars individually and in groups, and getting the message across to them.

One other development is helping us also. An increasingly large number of scholars are being involved in our processes.

Senator MacKenzie has raised a point about law and research grants. I might explain that each research grant is put before a group of assessors, selected in relation to that particular application. This means that anything which comes from a law school will be evaluated by legal scholars, not by political scientists, or anthropologists or such people.

By this method, as has been mentioned in our brief, we are actually involving three times as many scholars in the process, as assessors, as are involved as applicants. Many people in Canadian universities—and in universities abroad, for that matter—are beginning to learn about the sorts of programs we are trying to run. I hope that the problem of communication will be solved, in time; but we are still very much concerned about it and we are trying to introduce new devices for breaking down the gap between ourselves and those scholars with whom we are concerned.

Senator Grosart: My question was not directed primarily to the communications problem but rather to the policy problem. I have tried on various occasions to determine from the annual reports and the list of grants what the policy was. At times I have decided that I thought I knew the policy of the Council; but then, when a new list of grants would come up, I would say to myself that my previous opinion was wrong.

Is there a statement of policy? Or, do you rely completely on applications—which, I suggest, is an unscientific way to spend this amount of money.

Mr. Milligan: The straight answer is that we rely essentially on applications. We rely on the initiative of scholars. Our mission in life, our principal mission, is to provide a source of support for the kind of research which career scholars wish to do and for which there has been very little support, except from American sources, for a long period of time. There has been money available from royal commissions, from Government departments and from industry, for the kind of research which serves the policy ends of decision-making bodies of that sort. There is no support for the kind of work which the scholars decide they wish to do, particularly on the frontiers of their own disciplines.

This was our starting point in the Council. We are hoping to involve the community of research scholars, through its learned associations, or through such bodies as the Social Sciences and Humanities Research Councils, in the assessment of what is being done by career scholars, whether with our support or with support from other sources, to tell us where the strengths and the weaknesses are, to suggest what should be done to correct the weaknesses, to suggest the areas in which scholars should put forth greater research effort.

We feel that such guidance must come to us essentially from the scholars themselves. There may be a role in this process for those more directly concerned with the policy needs of Government at various levels, or of industry; there may be a need for a partnership between such people and the scholars in working out where the needs for greater effort may lie. The Canada Council is essentially a bureaucratic organization; I am not sure that we are qualified to suggest to the research community what it should be doing, and I am equally sure that, if we tried to do so, our suggestions would be resented.

Dr. Corry: Mr. Chairman, I would like to make a comment on what Senator Grosart has said about trying to draw out those who ought to be doing research which is needed. I have had considerable experience on this point over a period of years, on several councils which had money to spend for research purposes. On three occasions, at least, the council in question decided that a particular area ought to be explored very carefully, our opinion being that it was a very important area for the purposes of the country and the community. We looked around to try to get persons who would be willing to take up such a research project which, in our opinion, ought to be part of the general scheme.

The experience with this, whether it was our fault or not, was on the whole rather bad, because some of these fellows were finally traduced with some money to do something which we later learned they had not really wanted to do all that much, but because they were being given resources they said, "Yes." But either they laid down on the job or they delayed or they did not get at it because something else had caught their attention. My impression is, therefore, that it is very difficult for any agency like this to organize specific research activities and draw people in by the "carrot" of money support.

My own impression, as the result of those experiences, is that it is better to encourage people to see that there are possibilities and then let their own interests and inclinations attract them or draw them in rather than to try to create research projects for which you then go out and try to find people to carry them through.

This may not be the universal experience, but it was certainly the one that I met on each of these occasions when I got into this.

Senator Thompson: Mr. Chairman, may I point out that sometimes we have nervousness over bureaucracy research, particularly music and the arts. I suppose you will always hear of some cases where a person was not given consideration, but, on the other hand, his radical proposals may have been the means of changing our society. I suppose those people on the panel, who are chosen on the Canada Council, have really become part of the establishment of either the scholastic community, the music community or the artistic community, otherwise they would not have been chosen to be there.

What is the changeover on these panels and committees in order to permit the fresh voice of innovation and of radical people to be given some recognition?

Mr. Milligan: It varies between the different levels of panel or adjudication. At the top we have what is known as the Academic Advisory Panel, a body of 15 members. One-third of this panel changes every year. I suppose that in a sense this might be regarded as being an establishment group. I think it is a mixed group. It is not named by established bodies. The panel is, to some extent, self-perpetuating, with the actual appointment to be made by the Council. There is a good deal of consultation in the scholarly community about who should be on the panel. This is really a final review of the body.

Below this, in the process of adjudication in both doctoral and faculty fellowships, we work by a system of committees which are reconstituted every year. In each committee we try to get a reasonable variety of approaches and biases within this discipline because there are scholarly schools which we have to recognize are often competitive and very often hold one another almost in contempt. We have to allow for this.

Then, for the research grant program there are in fact no standing committees at all. Each application, as I said, is sent out to a selected group of assessors which is picked on the basis of the application itself. I doubt if any two applications are ever looked at by the same group of people. The number chosen will depend upon the complexity and size of the project. It may be three; it may be five. We have gone as high as eight in some cases.

In selecting people, which we do through consultation, we try to recognize variety throughout the scholarly community. We try to be sure that we get reasonable representation of different points of view so that they can all be brought to bear on any one application, but, in relation to the subject matter, they are all points of view of specialists.

Senator Thompson: Do you feel that the Canada Council has, in giving grants, incurred great public outcry in its choice of projects? The story of the sculptor Rodin comes to my mind. I think of the frustration he endured under the grant system, trying to get recognition throughout his life. Although I in no way, for example, can judge a sculptor or artist, I cannot help feeling sympathetic for the cause of someone completely avant garde trying to get some recognition in the community—and I question that he will get recognition.

Do you not feel that if you had more of an outcry on the choice of your recipients that it would perhaps be an indication that you are ahead of your times? Personally, I do not know.

Mr. Boucher: Mr. Chairman, if I may add a word, I do not think we have any qualms in saying that we are public servants or bureaucrats. That is what we are. But when we say that, we do not necessarily use the word in a pejorative sense. We merely mean to say that there are limits to what our role is. We should not try to do what we are not appointed to do. On the other hand, we have no hesitation, I think, to say that our system has certainly shown as much imagination as our parish has been able to show. We have no hesitation to say that it is not the more imaginative, creative, or enterprising applications that have been turned down by the Council. In fact, we have supported a number of applications which have been found to be rather disturbing by some members of our panel and of our Council. So it is not in being progressive that we may have been really lacking.

I think that we have to say, going back again to the history of Canadian scholarship in the social sciences and humanities, that it is a long-starved community. It is a community that really never had the resources to do what it wanted to do, and in which there is a tradition of people who are now at our age but who very early in life gave up on scholarly endeavours. Very often now our problem is to try to reach those who still have faith in the advance of knowledge —the young ones and the not so young ones who have pursued scholarly work—and really to support the ones who have imaginative projects.

We have always tried to do that. We have always subjected all the applications to the most demanding standards that you could think of, including international assessments, and I think generally we have reason to be rather proud, not of all the projects we have supported but certainly of a very good many of them each year.

Every time a press release comes out there is mention of one or two things that are really unusual in what we support—not only on the artistic side but even on the scholarly side.

Senator Grosart: You have been "swingers" on occasion.

Mr. Boucher: We can be.

Dr. Corry: If I could offer some testimony on this particular point, Mr. Chairman, you may have noted that, when Mr. Boucher was saying that he found members of the Council raising eyebrows about some of the projects that had come forward from assessors and panels, he was looking at me. I can safely say that there has been no lack of these proposals. Whether they are properly called radical proposals or not, I call them adventurous, and many of them have brought me up with a start. I have protested from time to time, but, with all those who are sympathetic to adventurous or radical projects, I almost always lose the argument. So I do not think it is fair for us to say that we are imposing a kind of conservative, small "c", *imprimatur* on these things. Part of the difficulty is, of course, that any fellow who is turned down is going to think that this place is a complete horror and that something ought to be done about it. I am not sure he is always right.

Senator MacKenzie: Growing out of Senator Grosart's point, and in view of the unquestioned influence and importance of the press and radio and television, my first question is weather this area has been surveyed with a view to discovering whether there are individuals or fields of interest in this most important area of our lives that could properly be assisted with funds from the Canada Council.

My second question has to do with age, and I would like to deal with that separately. I would be grateful if one of the members of the Council here present could deal with my first question. I have in mind the Nieman Fellowship and the Atkinson Fellowship to be held at the University of Toronto which is designed for journalists and others. These I think have been imaginative and useful. Also, and I hate to say this because it amounts to academic heresy, these people have far more influence on our society than all the Ph.D.s in the humanities and the social sciences put together. I will, perhaps, withdraw the social sciences and just leave the humanities. I am really serious in my view that this should be given consideration in terms of study of the field and of assistance to those working in it. I don't know of anything that gets more discussion in the Senate and in the committees of the Senate than some of the media I am talking about. I think perhaps you would be performing a public service if you could recommend something. My other question is a different one.

The Chairman: First of all, does any member of the Council have a comment to make on this point?

Dr. Corry: I would say that I agree with Senator MacKenzie in deploring the fact that we do not make greater impact on the humanities and social sciences, mainly on the humanities but I think there is a difficulty in expecting quick recommendations and results from studies that go on in the humane areas. We have had leaders in this field who in their day and generation have been crucified for their efforts, and their influence was a long-term influence. I am not sure that it is not something of the same kind that is at work where you have people working in the humanities who do not make as fast an impact on the world as people who deal with other things that you can quantify and measure, and as people who have an immediate impact on the application of these things to our social system.

The Chairman: Could we pass now to Senator Belisle.

Senator Belisle: Under this heading "The Canada Council's Programmes" in paragraph 14 you say that there are 10,600 university teachers and that only 7 per cent of these will be assisted this year. Is this assistance offered on the basis of a certain amount for each province or is it offered on the basis of their merits?

Mr. Boucher: On the basis of applications and on the basis of adjudication. We have received applications from approximately 1,000 university teachers during the course of the year and we have been able to award something like 750 research grants or senior fellowships to that group. So it is on that basis—simply on the basis of applications—that they are selected. We have no provincial quotas; we could not administer provincial quotas.

Senator Belisle: Is this an increase over 1966, for example?

Mr. Boucher: Oh, yes. I do not know whether members realize the amount of work involved in simply handling the demand, let alone in anticipating which direction it should take. There have been days during the course of the year when as many as five or six applications would come in, and an application is an elaborate presentation of a project which calls for a lot of work from an officer who has to follow the application for several weeks. Now, we have been able to cope with the growth of the demand—this is another important fact,—and the additional funds provided by the Government have really allowed us in very recent years to build up the demand and really to cope with it more or less as we went along. We have not been and we cannot say that we have been really sadly short of money in view of the demand placed upon us. The problem is that our parish is only discovering our existence and the size of the demand in one years' time, two years' or three years', is a matter for speculation. We have reason to believe it will be far greater than it is now. The pool of applicants is of the order of 10,000, and the number of applicants among career scholars has been of the order of 900 or 1,000 this year.

Senator Yuzyk: I want to follow up this question and in doing so I realize the fact that the processing of such a large number of applications means you must have an increasing staff every year. Could you give us some idea of how large your staff is—the technical staff at least?

Mr. Milligan: When I joined the Council a little over a year ago there was one officer concerning himself entirely with the social sciences and humanities and he had been with the Council for less than six months. I now have working with me five other officers and one who is on a part-time basis during our peak period, making a sixth. We expect that next year there will be a 25 per cent to 30 per cent increase in the volume of the applications and we will need one more full-time officer. We have provided for this for next fall. I think Dr. Boucher is a little low in his statistics when he says that there are days when five or six applications come in. Sometimes we receive 20 applications in a day, and generally we receive at least five or six a day.

When we say that 7 per cent of the eligible scholars received support in the past year, this does not mean that 93 per cent have been disappointed. In fact, fewer than 10 per cent applied. I would expect that if we had an adequate interest in research in Canadian universities the volume of applications in any given year would be approximately 20 per cent of the total number of career scholars. This has been the experience in the United States and probably in the natural sciences in Canada as well.

Senator Yuzyk: Do you find you are behind in the processing?

Mr. Milligan: At this time of the year we are, for this is the time of the year when we get applications for grants for summer projects. By the end of April, I would expect we would pretty well have caught up although a large number of grants then pending are not made until the end of May, when the Council meets.

Senator Yuzyk: How closely do you adhere to the deadline? If an application comes to you one day after the deadline, do you reject it or do you take it into consideration?

Mr. Milligan: No, we do not. The deadline applies of course only on fellowship programs. These are the only programs that have deadlines. We try to have them submitted by the deadline, but we are not rigid on this. As far as research grants are concerned, we are still hoping we can maintain this as an open-ended program which has no deadlines; we will accept applications any day of the year.

Senator McCutcheon: Mr. Chairman, I was wondering what assurance, if any, the Council is in the habit of giving to the recipient of a grant who will obviously require the grant for a further year or two in order to carry out the exercise which the Council has initially approved.

Mr. Boucher: If I could answer Senator McCutcheon on this: we advertise that we are prepared to entertain applications for research projects extending to three years, up to three years, the implication being not that we rule out projects that would extend beyond that period, but that we are not really making any formal commitment beyond that.

Our arrangement with the Auditor General is such that we cannot approve, in any given year, support for three years without encumbering the funds. So we have found a device which would allow us to grant support for the first year and to indicate willingness to maintain support in subsequent years, upon satisfactory progress, without really having to encumber in one single year all the three-year resources required. That is what we do. We inform the applicants that money has been granted for the first year of operation, that we have looked at the budget for subsequent years, and that the Council is willing to consider favourably applications for support, at the levels indicated, for subsequent years, upon satisfactory report.

Senator McCutcheon: Thank you very much.

Senator Grosart: Mr. Chairman, one sometimes hears criticism—and I am not necessarily associating myself with it—that the Canada Council grants are, on occasion, given to persons who could well finance the projects, or should be able to finance the projects, out of their own resources. This applies particularly to people who are very well established, who have very substantial incomes. I have heard it said that the Council sometimes forget these funds come from the public and from people who are denying themselves some of the necessities, for example, to put their own children through university.

I am not suggesting that this should be a means test, but I am wondering if Mr. Boucher could tell us what the policy is in this regard, because it has been a matter of public criticism at times.

Mr. Boucher: I suppose one would have to make a distinction between fellowships and grants. Of course, fellowships would go to certain senior students whose parents are wealthy and, perhaps, could afford to complete their studies without the assistance of the Council. We have no way of investigating the private means of applicants, and I think the alternative would have to be a means test. I do not see any other solution than that we would have to apply a means test in this regard.

When it comes to research grants they never include any stipend, but only cover expenses. They have to be thought of as a recovery of expenses that have to be incurred. I doubt very much that one could make a very strong case for Canadian scholars being personally capable of financing their own research. There may be, there should be, there must be a percentage of Canadian scholars who have personal wealth; but I think we can be reasonably assured that they are a small minority. Therefore, the setting up of an elaborate system to track down those who could do it on their own private savings probably would be more expensive than the few grants that we might make to wealthy people.

Senator Yuzyk: Is there not the prestige angle attached to it too—some would like to get a grant or scholarship because it comes from the Canada Council?

Mr. Boucher: The Council is very much aware of that. It is more evident on the arts side than on the academic side. Now, the Council does not give blessings. It can only give money, and we have to be quite candid about that. We do not support things just because they are good, but only when we can invest money in them. They have to go through the system of adjudication, and if they fail they are not going to get any form of moral suport. The Council is not in a position to give moral support, but only financial support.

Senator MacKenzie: My other question has to do with the influence of age on your decisions. I have heard it said rather loosely, or without too much consideration, that no great work in the sciences is done after a person reaches the age of thirty. I would be prepared to extend that a little. I would be inclined to say that in the case of the Humanities—possibly the Social Sciences and Fine Arts—perhaps experience brings some wisdom and judgment, in a practical form.

What would be your attitude towards an application from Dr. Corry, after he leaves Queen's next July?

Dr. Corry: I am all ears!

Senator MacKenzie: This is a question, because within the past year, I have had inquiries, letters, from individuals who did not get grants and who asked me whether it was because of their age. One of them was an artist, possibly pushing seventy, and another, in another area, a social scientist, I would think round sixty-five or so.

I can understand the value of investment in young people, because you expect to get a long-term reward, but what about a person who has laboured in the vineyard for many years? Should not he be considered for recognition and reward? I am thinking, again, of individuals like Dr. Corry.

Mr. Boucher: I should have hoped Dr. Corry would answer this! I should say that we have always been careful on the administrative side of the Council to screen out from assessment reports any rating which seems to be related to factors like this. We cannot stop our consultants from reaching judgments which may rest on this type of argument, but it usually comes out in the assessment, and then we look at it twice to find out whether the argument is well founded.

I think that age, as such, is not a relevant factor. But it might well be, on the other hand, that having moved into a discipline several decades ago and having been trained in that discipline at a time when it had reached a certain development, it might be that a scholar would not be equipped to handle the new techniques, if that is what he intends to do; he may not be fully trained to do research that way. This appears to be a reasonable comment on his application. But to state simply, on the mere ground that he has reached a certain age, that he is incapable of undertaking a certain project, is not a fair comment.

Senator MacKenzie: I have again in mind the point raised by Senator Grosart earlier, about the areas for investigation. For instance, two or three studies have been conducted by the Senate, one recently completed with important results by Senator Roebuck on divorce. If age had entered into his work there might have been a very different result. Senator Croll's committee which studied aging, and a number of other committees studying other areas of importance, have been headed up by people who are, shall we say, well along in years.

Mr. Milligan: There are young men of all ages, and old men of all ages.

Senator MacKenzie: Quite, and I am satisfied as long as you realize that.

[*Translation*]

The Chairman: Senator Desruisseaux.

Senator Desruisseaux: In considering the conclusions made in your presentation with respect to a scientific policy for Canada, I have been wondering, as a layman, whether the whole policy that we find here is actually the one being followed by the Council. That is my first question.

Mr. Boucher: I must say that the principles laid down in these paragraphs are those on which the Canada Council's policies are based at the present time.

There are of course certain fields which do not come under our jurisdiction, but are relevant to government policy. We do not develop government policy with respect to the allocation of funds to different items of expenditure. However, as is suggested in paragraph 22, we believe very strongly in the principle that all the learned societies should be closely involved in the development of a science policy. We make every effort to follow this principle.

Senator Desruisseaux: Then, if I understand correctly, the Government has entrusted to the Canada Council the policy to be implemented?

Mr. Boucher: The Senator is raising a very complicated problem, that of knowing what happens to the autonomy of the Canada Council in its present financial situation. It is obvious that when the Council was set up, it had both the responsibility and the mandate to develop its own policies within its particular fields. The government and Parliament, at that time, created an independent body to which they entrusted the responsibility of developing a policy on the basis of the resources placed at its disposal. Now that the Council has become increasingly dependent upon annual parliamentary grants that account for a higher and higher proportion of its total budget, it is obvious that the Council will have to maintain a dialogue with the government and Parliament in order to convince them that such additional funds will serve purposes that the government and Parliament will consider justified. I do feel however that even in such a context, where the Canada Council's programmes will come under increasingly close scrutiny, the Council will still remain a solely responsible and accountable for the validity of its policies.

Senator Desruisseaux: In the procedure which has been followed, has it been the custom for instance to submit proposals to the government for its approval, or do you abstain from making such proposals?

Mr. Boucher: We have been dealing in this way for only two or three years. Only the grant we shall be receiving next year can be said to have been the subject of anything resembling a submission to the Treasury Board. Previously, the grants we received from the government had been made on the basis of recommendations addressed to both Houses and approved on the basis of what I would describe as very general statements of the needs of the Council. But in the case of next year's grant, we have submitted something that perhaps comes close to a departmental submission, with less details than are provided by departments, but with an explanation indicating that the Council was engaged in the implementation of certain programmes for which the Government had already provided funds in the knowledge of the use that was to be made of these monies, and that the further implementation of these programmes called for additional funds.

It is therefore quite clear that if the government and Parliament have provided us with additional funds, they were aware—perhaps not in detail, but in a general way—of the uses to be made of such funds, though perhaps not in as much detail as in the case of a department. That raises the whole question of the Council's degree of autonomy, considering its position as perhaps the most unusual legal animal on the whole Canadian scene.

Senator Desruisseaux: On page 6, you discuss the matter of a science policy for Canada. Does this cover all the Canada Council's wishes concerning Canada's future, or the building of the future if you will? Are these all your recommendations?

Mr. Boucher: No.

Of course you will have noticed that there are very few comments on the suggestions put forward by the chairman of this committee. Our main purpose in this section was to indicate that in our view, it is essential, before going into specifics, to come to an understanding on broad objectives. When consideration is given to more specific suggestions, the Council may have some comments to offer. However, there are no comments in this paper on the advantages of having a department of science, or a social science research institute. There are no recommendations of this kind at the present stage.

Senator Desruisseaux: Thank you.

[*English*]

Senator Grosart: Is the Canada Council grant a single vote in the Estimates?

Mr. Boucher: Yes, it is. It is also listed as a grant.

Senator Grosart: Yes.

Senator Belisle: Can I ask a further question?

The Chairman: Yes.

[*Translation*]

Senator Belisle: Your requests are made annually. Does the government, in granting the funds and in accepting your request, indicate that you must follow a certain policy, or...

Mr. Boucher: No.

Senator Belisle: ...or are you allowed the same degree of autonomy as you had in the beginning, when the Council was set up?

Mr. Boucher: It must be said that the government does not necessarily accept our requests, and that in this way it can take a different view of the needs we have to face. However, the government has so far made no specific comments on the programmes we are trying to implement. A year or two ago, it endorsed the main lines of our programme by granting us the exact amount we had indicated was required for the implementation of these programmes. They have not changed since then, and we have had no comments from the government.

I think the government would hesitate before attempting to comment on the validity of the Canada Council's present policy. I think it would rather tend to express its agreement or disagreement through the level of subsidies that it would be prepared to recommend to the Houses.

The Chairman: Senator Bourget?

Senator Bourget: In fact, of all the monies granted to you by the government, only a very small portion is ear-marked for programmes suggested to the Canada Council by the federal government. Is that not so?

Mr. Boucher: Yes, that would be a way of putting it. On the other hand, it could be said that when the government recommended the establishment of the Canada Council to both Houses, it had in mind a general objective. Its decision to establish the Canada Council was based on a policy; its purpose was to achieve governmental objectives. The ways and means of achieving this objective were left to the discretion of the Council.

Senator Bourget: In fact, you have complete autonomy?

Mr. Boucher: If by that, you mean that there is no interference, that is correct.

Senator Bourget: Thank you.

The Chairman: Senator Desruisseaux.

Senator Desruisseaux: Another question. What is the relationship, at the present time, between the Canada Council and the Commission for UNESCO?

Mr. Boucher: The Canada Council is, as it were, the host of the Canadian National Commission for UNESCO. Mr. LeBlanc as chairman of the Commission, would perhaps be more qualified to answer this question.

Mr. Leblanc: It might be said that Canada's relations with UNESCO are at the present time partly farmed out to the Canadian National Commission for UNESCO, in association and co-operation with the Canadian Department of External Affairs.

Under present arrangements the Department of External Affairs hold a permanent seat in the executive of the National Commission, and the Commission's activity is based mainly on UNESCO's programme, which is prepared at its biennial meeting.

This programme shows the areas in which UNESCO plans to direct its activities over the next two years, and the programme is then completed by a budget. Up to the present time, the Canadian National Commission has set up committees of experts in the natural sciences, the social sciences, education and communications. These committees make exhaustive studies in commissions set up by UNESCO, and the results of these discussions are summarized in reports which are then sent to the Canadian Department of External Affairs.

Secondly, the Commission participates in a general way in the work of the biennial assembly. It makes suggestions as to persons who could officially be selected to serve on the Canadian delegation. However, it is the Minister himself who has the final decision and who appoints the members of the delegation.

In addition, the Canadian Commission for UNESCO keeps abreast of all activities initiated by UNESCO in Paris or elsewhere, to ensure adequate Canadian participation. If there is, for example, a meeting of physicists held under the sponsorship of UNESCO, the Canadian National Commission will see that the responsible organizations are advised, so as to ensure representation. This also applies to other fields.

Thirdly, within Canada, the National Commission constantly strives to publicize the work of UNESCO, i.e. the main projects on which UNESCO is working. There are a number of these, such as the distribution of the *Courier* and of other UNESCO publications, in addition to certain projects aimed at school-age children.

I wonder if this answers your question adequately.

Senator Desruisseaux: Very well indeed, Mr. Leblanc. Thank you.

[*English*]

Senator Grosart: Mr. Leblanc, did I understand you to say that the committee of the Canada Council nominates UNESCO delegates from Canada?

Mr. Leblanc: No, this is the Department of External Affairs, but the National Commission for UNESCO would make recommendations on people who may be invited to join the delegation.

The Chairman: Recommendations which are not always accepted.

Mr. Leblanc: They are not always accepted.

Senator Grosart: Thank you.

Senator Thompson: Mr. Boucher, I notice in your preliminary remarks, in your statement, that you suggest an emergency in our race against the clock in connection with obtaining research background and so on. Then on page 2 there is an inference where you suggest that in the United States the social sciences research budget of the federal government, although still comparatively modest, has been increasing 30 per cent faster annually, and in Canada it has been about twelve fold in growth. I would suggest that when you think of race riots and other things in the States one might perhaps wonder, as a sceptic, whether their grasp of knowledge is helping to achieve a better society or not.

I would say that I myself believe very much in the work of the Canada Council, but apart from your independence to some extent from public funds, you are really asking for public funds. I appreciate the problem Dr. Corry raised, that many of these ways of improving the quality of life are long-term, yet are you now in a position to show how this is developing the quality of our country? Can you now look back to the effect of your policies in certain areas and say, "If we had not moved there would have been stagnation in that area," or do you have to wait a few years and then perhaps you can say this? When public funds are being used the public likes to see, for example, the ballet and various other intangible projects which are to be encouraged. Are they giving a high quality to our society? I think there are sceptics in Canada about the Canada Council. What is the way in which you make your case to the public?

Mr. Boucher: I do not suppose we are being asked to comment at the moment on the value of our support to the creative and performing arts, but rather on the value of our support to the social sciences and humanities. I think it would be only fair for us to have a little respite before passing judgment on achievements, since we have not been in business for more than two or three years and a good many of the projects we have been supporting are not yet completed. The only thing we can fall back on is really the relativity between whatever support is available for the social sciences and the humanities and what is available for the natural sciences.

Without making any invidious comparisons, I think it is fair to say that support for the social sciences will be subjected to more suspicious scrutiny than support for the natural sciences. This is easily understandable, because the natural sciences deal with mysterious things and the public has no clear understanding of what is being done with its money in that instance. Of course, it probably would be fair to say that there is no reason to believe that the money is better spent there than if it were spent on the social sciences, just knowing human nature.

On the other hand, the pace at which we have grown in the past two or three years certainly is not indicative of the pace at which the Government is prepared to see us grow over the next few years. Already, next year, our increase in the parliamentary grant is not likely to be of the same order as that of the other two councils.

When we say that a "race against the clock" is on, this is intended more in the form, actually, of a critical assessment of the capacity of social scientists today to handle problems of growing complexity.

Social scientists themselves acknowledge that they have not proceeded far enough in the development of their own disciplines, to be able to cope adequately with the problems to which they are addressing themselves. Therefore, before any definite contribution can be made by social scientists in many vital areas concerning our future, some essential preliminary work must be done in the development of these disciplines, which are still very largely underdeveloped.

If you count the number of years which we may have at our disposal to resolve most of these issues, and if our salvation rests with the capacity of a number of disciplines to provide adequate answers, and if we acknowledge that these disciplines are still very largely underdeveloped, we must come to the conclusion—a poetic one, if you will, or a scientific one, if you will—that a "race against the clock" is on.

Dr. Corry: In attempts to judge what return the community gets for this kind of support, there will always be many intangibles, and these no one will be able to judge very accurately.

There are some things you have to take on faith, the main such thing being that, in a highly complex society, in danger of getting muscle-bound at every turn, substantial amounts of resources must be put into these attempts to understand it and make sense of it. That is one thing you must take on faith because, if you do not make that judgment, the whole problem becomes very difficult.

What are some of the intangibles? There are two programs about which most has been said in the brief. One is the fellowships. I think it is clear that the Canada Council fellowships are helping substantially to keep young people of excellent ability at work in universities, a very large number of them preparing themselves to be university teachers in those subjects where we need more elucidation for a larger number of students. The shortage of university staff is still very acute. One cannot measure the money value of that, except in relation to the number of people we manage to keep as teachers working effectively in the universities.

On the subject of research projects, I would not wish to feel obliged to affirm that each such project will unfold invaluable results for the community in general. No research project, in any subject, can be counted on as sure to do this, although a substantial number of them will do so.

There is another factor in this, which relates also to the universities and the teaching community. There is more hope of keeping an adequate number of young people preparing themselves for university work if this kind of support in scholarships is available while they are going through, and if research funds are available when they have finished their studies.

We must not forget that in our society as it now is there are a hundred other things which a very bright fellow can do besides sitting in a university and teaching or doing research. Even if all we do is keep an adequate core of these people where they should be, we shall have accomplished something of considerable importance, even though one may not be able ultimately to measure how much return in money terms there has been to the community for the amount of money which has been put in.

The Chairman: There are relatively good figures showing the expenditures, by the Federal Government and by the entire Canadian community, devoted to research in the fields of physical and life sciences. I wonder if we have the same information regarding the social and human sciences?

On page 4 of this presentation, I note that the Canada Council is "pressing" for the establishment of a "continuing national inventory of research activity in the social sciences and humanities". What is meant by the word "pressing" in that context? And whom is the Council pressing?

Mr. Boucher: The Council had thought at first, to meet its own needs, to keep this inventory itself. It has now an indication—from the Social Science Research Council, at least—that this is one function which the Research Council might wish to perform. Therefore, the Council has pressed the S.S.R.-C. to proceed with its plan on that point, and has indicated its willingness to support financially in such establishment. Some definition of positions will occur within the next months—quite possibly, around the meeting time of the learned societies this spring. A continuing inventory will probably be in the process of establishment within the next twelve months.

The Chairman: For instance, in terms of expenditures devoted to research by the Government, I understand that we really have no figures at the moment?

Mr. Boucher: That is so.

The Chairman: And you are not aware of any agency which is preparing such figures, that is, any agency such as the Dominion Bureau of Statistics?

Mr. Boucher: There is a small committee of the Privy Council which keeps tab on expenditures in what is called the behavioural sciences. That would provide information and expenditures by departments, including expenditures on economics, but not including the Canada Council. This adds up to something like $4 million a year for the federal Government.

You are quite correct, Mr. Chairman, there is no comprehensive census at the moment of the amount of support given to the social sciences and the humanities, from all sources. We were very concerned about that a year and a half ago, and we were in the process of staging such a survey when we learned that the Science Council had apparently decided to make an overall survey of the financing of research in Canadian universities, and thought that it would have to include the social sciences and the humanities. So we joined forces with them, hoping that the information we were seeking might be collated through the Macdonald Survey. It is doubtful now that the Macdonald team will produce comprehensive figures in this field. So the Council is back at its original problem and will have to decide whether this sort of comprehensive census can profitably be staged today.

It raises all sorts of difficulties, mostly concerned with fringe areas. It would have been preferable to have a comprehensive review of support for all disciplines.

The Chairman: But this Macdonald survey, as you state here, will deal exclusively with university research.

Mr. Boucher: Yes.

The Chairman: It will not deal at all with research done by industry or by the federal Government in its own departments.

Mr. Boucher: No. Oh, it will deal to some extent with what Government departments do, but there again it is not approaching its task as implying that it should come up with comprehensive totals for any of these fields. I think it should provide more or less spot-check information in various areas.

The Chairman: Do you not think it would be desirable for the Dominion Bureau of Statistics to undertake this work rather than assign it to a private institution?

Mr. Boucher: Well, I am not sure that the Dominion Bureau of Statistics would be in a financial position or in a staff position to undertake this. The problem with the D.B.S. is always that it is so overly committed that it cannot really assume responsibility for any heavy additional work.

The Chairman: However, that would really complement their reports dealing with expenditures in the field of life and physical sciences.

Mr. Milligan: I think a good deal more is involved than a record of expenditures. What we and the research community are interested in obtaining is a picture of the pattern of research. What I have in mind is something along the lines of the Science Information Service of the National Science Foundation in the United States, which is an imperfect inventory at the present time. They still have difficulties in getting an adequate input of information about all research being undertaken, and in this respect they are particularly weak in the social sciences down there. This is the kind of service that has to be developed but which, as the director says, cannot be developed solely for the social sciences, if only because there is an overlapping of social sciences and natural sciences. So, essentially, there is a very large automated operation, with problems of input and problems of compatibility with what N.R.C. is doing, what the Americans are doing, what the French are doing and what the British are doing.

Senator Thompson: Mr. Chairman, did you not request at the last meeting of the Committee a research project bearing on the number of national agencies who were working in research? Am I right?

The Chairman: This project was rather related to the agencies interested in the work that would be done by this committee. They may not necessarily be doing research, but they may wish to appear before us.

Senator Thompson: Would that have been something that would have gone to you, Mr. Boucher, if you had had this set up? You do not have that information at present, I suppose.

Mr. Boucher: Actually, we are concerned about some peripheral aspects which, to us, may very well prove to be very significant. Take for example the amount of energy and resources put into consultation at the moment. If you look at what happens to a Canadian economist in a Canadian university, how much of his time does he spend, how must additional income does he make and how much in the way of expenses does he get for doing consultation, for working on labour disputes, for doing contractual research, for working for royal commissions, for contracting with Government departments and for doing free research which has to be funded by agencies like the Canada Council? This would be the total picture. At the moment we do not have the total picture. We do not know what our position is in the market. We do not know what our competitors are. We do not know what we are stealing people from. We do not know what we are losing them to. We do not have the total picture, and, not having the total picture, we cannot define exactly the financial dimensions of the role that we ought to be performing. But I am not quite sure that the natural scientists do not have that, too, except that they may be able to live with the situation, in that it may not appear to them to be as critical as in the social sciences.

The Chairman: At least in those fields of the natural sciences, through the D.B.S. publications, we know at least in terms of figures —and that is just the beginning of learning in that field—what are the budgets in the various federal Government departments and crown corporations which are devoted to each particular subject. However, so far as I know at least, we do not have that information for the social sciences. We do not even know the kind of duplications that may exist in Government departments in terms of grant programs and research programs.

Mr. Boucher: We know it for the federal Government.

Mr. Milligan: We know it at least for the grant programs, because there was a departmental committee headed up by the Special Planning Secretariat.

The Chairman: Has this been published?

Mr. Milligan: I do not know what distribution it has had. It is available. There is an analysis of research grants given by the federal agencies. For contracts I believe there is some record kept in the Treasury Board, but how detailed and how far it goes into the substance of the research I do not know.

Senator Thompson: Mr. Chairman, could we have that report for the committee?

The Chairman: You are referring to the report by the Special Planning Secretariat.

Mr. Boucher: We will give you the reference, Mr. Chairman. I might point out, Mr. Chairman, that there is a great deal of complacent satisfaction in the area of the natural sciences, for the extent of knowledge we have on these fields. If you look twice at it, however, they do not know a great deal more about what is happening to engineers than we know about what is happening to economists. If they talk about pure science, then I think they do know more, but when it comes to engineering I think their knowledge also suffers from the same limitations as our knowledge regarding the social scientists.

Senator Grosart: Mr. Chairman, it seems to me obvious that this data that we are discussing is absolutely essential to the successful work of this committee. I wonder if I may ask Mr. Boucher if he could estimate the magnitude of the complete job in terms of time, people and money.

Mr. Boucher: I think we would not venture an estimate. Every time we think that we know the answer, we discover something totally unheard of that just floors us.

Senator Grosart: It is just like politics.

Mr. Boucher: Just a few weeks ago I learned that a Canadian anthropologist had just completed a very extensive project of filming the life cycle or occupation cycle of the Canadian Eskimos, and he has had support from M.I.T. and the National Science Foundation in the United States to the tune of $900,000.

In fact, nobody knows how many projects like that there are in Canada, being done by Canadians on Canadian soil with American money. We just do not know. We learn of them occasionally and then we promptly come to the conclusion that it is foolish of us to try to estimate how much of this there could be. We just do not know.

Senator Grosart: Somebody has to make a start, however. What would be a reasonable estimate of the magnitude, just to get something down that would be reasonably accurate?

Mr. Milligan: Do you mean the cost of making such an investigation?

Senator Grosart: Yes.

Mr. Boucher: Oh, the cost of making an investigation.

Senator Grosart: Yes.

Mr. Boucher: I think the investigation would almost have to be not by sample but in the form of a census. You would have to circulate the whole academic community plus the professional economists or people who are making it a career to be consultants outside the university circles. You would have to ask them, "What support have you received over the past two or three or five years?" You would have to ask them whether it was in the form of contracts; whether in the form of grants; whether from private sources; whether from public sources; whether from Canadian sources or whether from American sources. You would have to ask what the account was and what it covered. Did it cover only expenses, out-of-pocket expenses, or did it cover a remuneration or a stipend? We would have to ask all these questions and we would certainly have to do so quite confidentially owing to the fact that Canadian universities do not know how much money their own staff are making in this way. So there is only one source of information and that is the people themselves and you wouldn't get the information if there was any possibility that it could be passed on to other people, such as the Income Tax Branch, I suppose. So it would have to be anonymous, and this is the only way you could find out. But it could be done. It would be a big operation, but it would be worth doing.

The Chairman: We are already in contact with the Dominion Bureau of Statistics, and perhaps at a later stage our research directors will be in a better position to report on their discussions with them. It seems to me that it could be very worthwhile also to try and organize a small group together, including the Dominion Bureau of Statistics, the Canada Council and perhaps the Special Planning Secretariat of the Privy Council. Of course, we are not seeking very exact and precise information. I do not think it is possible to get an exact measurement of our effort but at least we could have good approximations the same as we are getting—and I do not think they are any better than sound approximations—in the other fields.

A final question, if I may, which deals more specifically with the matter of a science policy for Canada. If I interpret the brief well, you seem to assert that the research community—and this is taken mainly from the top of page 5 and part of page 6—must have for all practical purposes or should have the responsibility for developing a proper and adequate science policy for the social sciences and the humanities. Not only should it develop that policy but it should also define and enforce its priorities and determine, through discussion, the administrative organization of that policy. This may seem to be a proper arrangement in so far as the restricted activities of the Canada Council are concerned. But when that attitude is applied at the level of a global national policy for the social sciences, it seems to restrict the Government to the role of a mere supplier of funds, in the expectation and hope that scientists in universities in choosing their research projects will adjust their own objectives with what ought to be the national interest. I would like you to comment on this question if it is not too general.

Mr. Boucher: It certainly is not our intention to imply that this is a responsibility which lies exclusively with the research community. I think we wanted to say that the research community has to be involved in the elaboration of any such policy. When people talk about a science policy, it is very hard to know exactly what it is they have in mind or what a science policy is expected to deal with. To take the critical point of whether a science policy ought to set up a list of priority areas which would be privileged, I think that we would say in the Council that this cannot be arrived at in any effective way without involving the research community, because it is the test of a priority list that it can be enforced, and the test of whether it can be enforced is whether you can really rule out from support things that don't fall in the list. We know from long experience that when you have a first class application from an exceptional scholar funds will be found to support that application whether or not it comes within a defined list of priorities. Therefore, what purpose does a list of priorities serve? It serves to indicate areas of concerns. If it is to be established by governments, it is likely to reflect areas of social concern. But those are not necessarily areas of scientific concern. Governments may encourage research for different purposes; they may encourage research because they believe that scientists must be kept here at home, engaged in their most creative endeavour and supported in that activity; or they may think that what scientists do is useful to governments, or they may turn questions over to scientists. On the other hand governments may also support research in order to provide a process of public education; this has been largely the role of the B. & B. Commission. But it does happen also that governments support research in order to breathe before taking action. There is nothing really wrong with that but there may be areas which are of real social significance and may well be of no real scientific significance. Nobody has really established that the problem of pollution requires a great deal more scientific investigation but it obviously requires a great deal of public education, and the decisions are difficult to take. But there may be a temptation on the part of governments to equate complicated social problems where political decisions are difficult with particularly promising areas of research.

These two things do not necessarily follow. This is not saying that scientists should not be engaged in assisting governments in sorting out priorities. What we are saying is that scientists themselves must be involved in this question ultimately. The more significant research will be the one that is scientifically meaningful rather than the one that is just socially meaningful. Therefore we are only urging that the social scientists themselves come together, that they start discussing what it is they are doing, that they compare notes and that they try to understand what they have achieved and where they have failed, if they have failed, both scientifically and socially. But they must be involved in this process and governments must watch this and they must intervene when it comes to setting up levels at which public funds are going to be disbursed. But I think if this exercise were really well conducted, the Government might well have little direction to give to a scientific community that would really be quite aware of its achievements and failures as it went along. I think that very largely scientists are capable of self coordinating their own work and that co-ordination from above, if it comes without having given the research community a chance to tackle this problem, might be highly resented and turn out to be ineffective.

The Chairman: I agree that if we want to have a global science policy, we need free research where the researcher chooses his own topic and gets assistance if, when making an application to the Canada Council, it is found that his project has merits and if there is sufficient money.

In addition, however, it seems to me that if we want to have an overall science policy in the field of the social sciences we must also have a sector where we would do oriented research, where specific areas would be defined beforehand and where assistance would be offered within that general framework.

This would avoid the gaps left by the free choice of the research community which may be interested in certain subjects but not necessarily attracted by more important national problems.

Dr. Corry: Mr. Chairman, I think it would be vital to maintain some kind of distinction such as you are making between free research and subject-oriented research, which has such a close bearing on problems of public policy that no Government that is trying to be intelligent can afford to overlook, and it must therefore see that that kind of research gets done.

I should think where it becomes apparently as urgent as it is, surely, the way to do it is through royal commissions, through individual departments of government undertaking within their authority to get these very urgent pieces of investigation made.

Perhaps the Canada Council can also serve, or other agencies like the Canada Council can also supplement this, to some degree; but the case for pretty substantial support by the Canada Council in these matters is that you can get people exploring the fringes of what is not seen by anybody today to be urgent and necessary. No one would have given Rutherford at McGill very much money from Government sources back in 1920, or whenever it was, because if there ever looked to be an unpromising line of inquiry it was this which led to the splitting of the atom.

You could translate that into all sorts of areas of investigation, where somebody will take up, if you have enough people working on it, these unpromising lines of inquiry, as they appear to be, and you will get breakthroughs of great significance. You will get it not only in the Natural Sciences but in the Social Sciences and the Humanities and, therefore, you need some agency with enough freedom to explore that kind of thing. But that this alone would be adequate for the community's needs, I would deny; it will not.

The Chairman: I was merely thinking, for instance, of the possibility of extending the scope of the Economic Council to cover the whole field of Social Sciences—something of that sort, where you have very serious but mission-oriented research which complements the sector which is the main responsibility of the Canada Council—namely freely initiated research.

Just a final, very small question which arises from your report. The Canada Council has accepted the responsibility for the exchange program with French-language countries, where apparently you are dealing with all kinds of sciences—nuclear physics, mechanical engineering, plasma physics, and all these subjects. It seems to me that these subjects dealing with the physical and the life sciences should come under the National Research Council. I am sure there is a reason for this.

Mr. Boucher: The reason is simply that the Department of External Affairs has had monies voted to it to maintain a program of fellowships and grants to foreign scholars, and this now extends beyond the French-speaking countries to include the Netherlands.

Mr. Milligan: The Netherlands, West Germany and Italy.

Mr. Boucher: West Germany and Italy next year. This program, of course, is for the support of visitors to Canada. I do not think External Affairs are prepared to decide that so much money each year will go to the social sciences and the humanities to be administered by the Canada Council, and so much to the Natural Sciences to be administered by the N.R.C. It was for the Canada Council to decide whether we would take over the program. We have agreed, we have set up special committees of natural scientists to deal with the Natural Sciences. So, there again, being an agency and not a team of experts ourselves, it is not really more difficult for us to set up committees to deal with this, and we are making recommendations for the spending of these funds in accordance with the assessments made by various peers of these applicants.

So, we do run the whole program for the Department of External Affairs, as the A.U.C.C. runs the program for the Commonwealth countries, and the N.R.C. has never thought this was really an infringement of their field, because it is quite obviously something unusual for us.

There is nothing in our act that prevents us from doing almost anything. At one stage—and this takes us back to the Killam gift—before Mrs. Killam died she gave the Canada Council a certain sum of money to run a program of assistance which extended to Engineering and Medicine.

Senator MacKenzie: This was anonymous?

Mr. Boucher: Yes, this was the anonymous fund. She wanted it that way, because she was interested in Medicine and Engineering as well as in the Social Sciences and the Humanities. Before really listing the Canada Council in her will as a very substantial beneficiary she wanted to know how we could handle a grants and fellowships program on her behalf. For several years the Canada Council gave awards in Medicine and Enginering. There is nothing in our act that says we cannot do that. The Canada Council could actually make grants for almost any purpose which does not run against its more specific mandate. At the moment, the Killam fund which represents a substantial amount of money, $17 million, is primarily for the social sciences and humanities but also with a very wide-open possibility to include interdisciplinary projects which would involve natural scientists.

Next year something like $800,000 will be spent on the Killam program, and an equal amount will be spent on international exchanges for External Affairs, and both these programs will involve not only social scientists and humanities people.

Senator Thompson: I understand our committee will be seeing the Government departments, both federal and provicial. Within the Civil Service there is always a tendency to establish a certain function that they will subsequently hang on to pretty steadily. We are trying to get a more co-ordinated picture of research grants with the experience you have in giving grants and in the distribution of scholarships. Is there any argument the Department of External Affairs gave for performing this function previously themselves?

Mr. Boucher: They never ran the program. From the outset, they farmed out the Commonwealth Exchange Program to A.U.C.C., and from the outset they farmed out the French-speaking countries' program—what was at first the French-speaking countries program—to the Canada Council. This has now been extended to include other countries, and it will go on being extended, I presume.

This is really in the form of a contract, if you wish, so far as we are concerned. We are prepared to perform that service. This is not part of our own planning. It is just that we are available, and we are willing to perform this role for External Affairs.

Senator Thompson: May I ask this in another way? Do you know if the Department of Agriculture provides research grants for studies in agriculture, and are these handled through you?

Mr. Milligan: We have to distinguish here between contracts and grants. There is some confusion because in some cases we are led to believe that what are in effect contracts are given in the form of grants, and what are in effect grants are given in the form of contracts. Virtually all departments contract for a good deal of reasearch that relates to their departmental responsibilities.

A number of departments have research grant programs, in which case the research plan is left in the hands of the applicants. They are very much like our grants, and in a sense they are a duplication of our grants. I think, from the point of view of the research community, this is actually welcomed, because it means that they have more than one string to their bow. They can apply to alternative sources for support, and this may not be a bad thing.

I would worry if the Canada Council occupied a monopoly position in research support in the field of the humanities and social sciences. We cannot claim to be infallible, even with the best assessors we can find in the academic community. There have to be alternative sources.

What must be judged is the proper balance between those fragmentary programs of the various government departments—and there are about 15 listed in this study done by the Special Planning Secretariat—and the omnibus programs of the Canada Council itself. The same situation exists, to some extent, in the natural sciences.

Senator Belisle: I move the adjournment of the committee.

The Chairman: On behalf of the committee, I want to thank the representatives of the Canada Council who have been very generous with their time in coming here this morning to enlighten us. I extend to them a standing invitation to come back, if they want to add to this initial submission. As far as we are concerned, I am sure we will remain in contact with the representatives of the Council and if they do not manifest an intention of coming back we might issue another invitation to them.

Thank you very much.

The committee adjourned until 3:00 p.m.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Tuesday, March 12, 1968

The Special Committee on Science Policy met this day at 3 p.m.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: I am very pleased to welcome Dr. C. J. Mackenzie, who has been good enough to accept our invitation to meet with the committee this afternoon. I certainly do not need to introduce him to you. I would merely describe him as the father of science and science policy in Canada. He has had a tremendous experience and a wonderful career. I understand that this afternoon he will tell us about his experience as Canadian scientific institutions developed. I think he was at the origin of most of them and also instrumental in giving new life to some of them. We are very pleased to meet with you, Dr. Mackenzie.

Dr. Mackenzie has no prepared submission and he would not mind at all if members of the committee were to interrupt him as he goes along. So you may feel quite at ease to ask him a question at any stage you want. This is your wish, Dr. Mackenzie?

Dr. C. J. Mackenzie, Chancellor, Carleton University: This is my wish, yes. Thank you, Mr. Chairman. As the Chairman has said, I have no formal brief, because I do not hold a brief for anybody. I have not been in responsible charge of anything for 15 years so I am completely free to express my own opinion, but I cannot express an opinion for any other group. However, as the Chairman has suggested, you might be interested if I were to give you some background material. When I say background material, I can go back to the very start, because the formal interest of governments in scientific research in Canada started in 1916. It was in 1916 that the National Research Council was set up, and I have been associated with or as an observer of the developments that have taken place over the years.

First I should like to say that I think in many cases we underestimate what happened 50 years ago. If one reads the history of the parliamentary committee which was established in 1919 to discuss the place of organized science and government activities one will find very lively debates on many of the questions that are supposed to be new today. I believe that a reading of history is a very good thing, particularly for scientific people, and I might say for other people as well. Incidentally, organized scientific development in Canada, and in the English-speaking world, was sparked by two world wars. Experiences in World War I awakened the United States and England to the national value of applied research in industry, and World War II brought about the great post-war revolution in scientific technology in all industrial countries. There have been many technical revolutions, but this is the first time we have ever had what was really a scientific technological revolution. The Industrial Revolution brought industry out of the cottages into factories. The second industrial revolution started with the substitution of mechanical power for physical labour. Road machines are a good illustration of that; one great big bulldozer can do the work of hundreds of men. The latest revolution has been sparked by the substitution of electronic energy for brain activities; one computer can perform faster and more accurately the mental operations of scores of humans, and such electronic devices have revolutionized a wide range of scientific industrial and management operations. As the application of science became big business the need for more government concern in scientific development policy became obvious.

When most laymen talk of the great developments in science they are really thinking about applications; it is the applications of science which affects our daily lives; development work that demands the large portion of the national scientific budget. Pure research is relatively inexpensive in the overall picture. In most countries only from 10 to 15 per cent of the total national budget for science is spent on fundamental research, so fundamental research, while of vital importance is neither a problem in overall financing nor government policy. People who can do fundamental work know what and how to do it, they know the needs. They should be given adequate funds and left alone to work out their own scientific policy.

When I talk about research and development today I shall talk only about research and development in the physical, biological and live sciences, and will lump together pure and applied science and industrial application.

Maybe I should hesitate a moment to say how pleased I am that this committee has been set up, because for a long time I have been feeling that there was a need for more informed communication between the parliamentary groups of the country and the scientific institutions of industry, government and universities, not to consider executive problems, but leisurely to look at long-term policy. Most executive arms of Government do not have time nor the continuity of personnel, necessary to build up a forum of well informed people interested in the broad impact of science on the country. This I think your committee can do, and it is the impact of technological developments on our political and social economy that needs study, not the specialized activities of science.

In considering such questions in England the House of Lords has been able to play a special part, because their lordships have the necessary time and knowledge to go deeply into broad scientific questions and provide a continuing forum for the discussion of these problems. As a result that body, without executive responsibility, has exercised real influence in connection with government policy.

Honourable senators, I hope you will not think me impertinent but speaking from long experience I would suggest that if your committee selects as its main purpose the holding of an ordinary inquiry—like that of a commission, hearing briefs and then making a final report in a few months—you will have done something but you will not have achieved that most important object, which must be a continuing study. I do not mean that you should continue to study one specific problem. I mean that without continuity of interest your reports, excellent though I am sure they will be, will be like scores of other excellent reports of ad hoc commissions and committees. Such reports so often are left to gather dust as soon as the committee has dissolved. On the other hand, if your committee has a continuing interest in these matters, you will build up real authority and influence.

It is extremely difficult for me to envisage, in any precise manner, such a thing as a "scientific national policy". The words do not seem to make sense. When we come down to cases, we find we are dealing with national government policy on matters involving science and technology. Many years ago Lord Haldane—a very able man, a philosopher, a barrister and a perceptive statesman—was chairman of a committee investigating the "Machinery of Government" in England as it emerged from the war in 1919. His report referred to "the importance of research in the formulation of government policy," and there was no talk about national scientific policy.

About 25 years ago there could not be any government policy on atomic energy, although there was scientific policy in laboratories, where the nucleus was being investigated. When the release of atomic energy became a practical reality of enormous public concern, there arose an absolutely urgent need for government policy.

In Canada the Government decided on such a policy in 1945—namely, that we should take part in the development of atomic energy for peaceful purposes, but would not make bombs. That is the type of important and general national policy which only governments have the right to make and which governments should make. The Government did not state how or where developments would be done, as this obviously was a matter for the executive arm of government, after taking advice from technical experts. This is my distinction between broad "government policy" and "scientific policy" in carrying out projects.

All are agreed today that in Canada there are many other such policies that should be formulated in the light of the growth in scientific technology. There are, as we know, departments dealing with day-to-day policy on such matters as defence research, space research, oceanography, pollution, etc. In all of those fields, I suggest there should be some over-all government policy, or at least guidelines, before departments and agencies are allowed to embark on ad hoc expenditures which may often determine, but not follow government policies.

The future policy of the government very often is determined by the activities and expenditures of government departments, without any reference to government over-all policy. This may not have been so wrong in the past and there was little complaint in the early days, but it should not be acceptable today.

There is little doubt that the early research in agriculture—that did so much for western Canada, which would be a desert were it not for the development of rust resistant wheat —was probably started as departmental scientific policy rather than broad government policy. But the expenditures were small and the work was done by real experts and no one could object, but today in all such fields there should be some over-all policy.

I would like to emphasize another facet with which broad government policy must be concerned. Today the opportunities for important research projects far exceed our available research manpower. This raises one of the most urgent and difficult questions—priorities—how to evaluate the relative importance to our own country, of the competing areas for research. I do not underestimate the value of dollars by any means, but the most important thing in promoting research is not dollars: it is qualified people. One thing we must always keep in mind is that if more dollars are provided than are required by available qualified people, the returns proportionally will be less in quality and quantity.

Determining priorities, of course, must involve matured scientists in establishing criteria for evaluating projects, but as the central concern is the good of the country the final broad decisions are matters for national policy. This is not something easy to achieve. People in all specialties are naturally crusaders and rightfully terribly enthused about their own specialties. As an example, medical scientists feel extension of medical research is the most important and urgent need of our country. A similar situation exists in all other broad areas such as welfare, space research, atomic energy and all other broad fields of scientific activity. They all feel Canada is falling behind in the parade if their specialties are not greatly extended. This makes it difficult. How do you write criteria? How do you establish relative importance and how do you read the future? There is no quick easy answer but this type of problem should, in my view, be of primary concern to your committee.

I would now like to speak briefly about the way in which Canadian science has developed. Up until the beginning of World War II, which is not very long ago, scientific research and development was treated very much like art, poetry and music. It was very much respected but meagrely supported. It was not generally considered to have much real impact on our material or social economy. However, World War II changed all that and did so very rapidly. Today few, if any, will deny that the material and economic strength in peace, as well as in war, is a direct reflection of a country's technological competence. The fantastic pace of the growth and applications of science, particularly during the past two decades has aggravated if not created a central problem which is before your committee. That is, how do we fit this new phenomenon—new in quality and more particularly in size—into a Victorian type of government policy-making apparatus? This is what we have been contending with for some time.

During the war there was in Canada a proliferation of crown companies. Why? Because the original Government organization was not set up to handle war of a scientific, technological nature. However, we are now getting into the same sort of position in our peacetime activities. This is a big problem but is not a new one, nor is it one which has not received much thought. On the contrary people in many countries have been grappling with this problem for many years, but I suggest that no nation has yet found the ideal solution.

I would now like to get away from philosophy and present some factual aspects to illustrate how scientific and industrial research has developed quantitatively in Canada. There is no question about the fact that the first step in involvement of a Canadian government in organization of science was taken on June 6, 1916. On that date a subcommittee of the Privy Council on scientific and industrial research was established, and in November members of the first National Research

Council were named and charged with wide responsibilities. Why did this happen in 1916? There were two reasons. First, the allies had become painfully aware that the Germans were far ahead of them in organizing and adopting the application of science for practical purposes in war and peace.

The Government of Great Britain set up an organization for scientific and industrial research and suggested that the Canadian Government do likewise, which was done.

Secondly, the war had seriously reduced the sales of many industries in Canada and their representatives also pressed for government assistance in making available to them the advantage of organized programs of industrial research.

In 1919 the Chairman of the National Research Council, Dr. A. B. Macallum, made many speeches across the country. He was a good scientist and fine crusader as well. He made four points that I am going to quote to give you some idea of how small our scientific effort was then. "In 1919 there were 37 industrial research laboratories in the Dominion of Canada that had one scientist" and "only seven firms that had laboratories with four or more scientists". So probably the total number of scientists employed in industrial research laboratories in 1919 was not more than 50 or 60; whereas today there are over 6,000 people employed in industrial research establishments in Canada.

Macallum stated that in the whole country there were only 50 qualified research people. Today we have what?—Eight to ten thousand. From 1896 when the first Ph.D. course was instituted in Toronto to 1919 there were only 11 Ph.D. degrees granted in the entire Dominion of Canada.

Now, how could there be much research when there were so few people qualified to do it? I suppose there was not a professor in Canada at that time who had a Ph.D. degree from a Canadian university. The National Research Council was instructed "to co-ordinate and promote science and industrial research in Canada." The Council members soon realized that there was nothing to co-ordinate.

How did the National Research Council start to promote scientific research? They did it by recognizing that the immediate task was to build up scientific research and teaching facilities in Canadian universities to supply the necessary scientists. They started off by granting scholarships, but they did not just stop at that. They also made research grants to Canadian universities, but they did something else which, to me, seems of basic importance. They said, "Unless we make these scholarships tenable only in Canadian universities for the present, our students will go abroad; there will be little development in university research facilities here, and Canada will still be more or less a colony as far as science is concerned." For nearly 50 years the National Research Council has continued to support, by increasing sums, our universities; and it is certain that if this had not been done the scientific and research competence at our Canadian universities would not have attained the high level found today.

In 1939 the total expenditure by the federal Government for research and development was about \$5 million. Eighty per cent of that was for research in natural resources and only 20 per cent went for what we would now call industrial research. I think the expenditures in natural resources paid magnificent dividends, but the support for secondary industry was limited in money and effect. The war changed all that.

In 1935 the N.R.C. had a total staff of 300 and a budget of about \$1 million. By the end of the war a direct and indirect staff of about 2,000 was directing research expenditure of over \$10 million. As N.R.C. was responsible for government support of scientific and industrial research, these statistics illustrate how the war accelerated Canada's participation in this area.

In 1963 I was asked to make a report to the Government on the organization of science. I will sketch briefly the picture as I saw it in 1963, before the scientific secretariat and scientific council were set up. In 1963 private industry was much more research-oriented than in 1939 and was spending \$155 million in industrial research. There were many efficient research laboratories, small and large, and about 700 companies with well-defined research programs. While the research and development programs of Canadian industry are less extensive than is desirable, the recent progress is impressive. The Dominion Bureau of Statistics reports show that from 1961 to 1965 the total number of people engaged in research and development has increased from about 4,800 to 6,400, and the qualified research personnel have increased from 1,000 to 1,500, of which 800 have doctorate degrees.

These statistics are impressive and will surprise many people. The expenditures reflect the same thing.

Over the years many Canadian subsidiary companies paid their parent companies for research knowledge. It is interesting to note that from 1962 to 1965 the total amount so spent has been reduced by about $4 million. If we put this reduction in the form of a percentage of the total research expenditures of the subsidiary companies made in Canada, the figures for 1962 and 1965 are respectively 20 per cent and 9 per cent. All of this is not to say that Canadian industry should not increase its independent scientific competence. I merely point out progress since 1929, and even more so in the last decade, has been in the right direction at an impressive rate.

From 1933 to 1963 federal expenditures on research and development have increased from about $5 million to nearly $300 million per year. While in my view the performance of Canadian scientists in the war years sparked this advance, we should not overlook the fact that the major increases which have occurred in the past decade were primarily civilian in character.

The expansion in university research activities from 1939 to 1963 were equally spectacular and I am sure representatives from universities and government research institutions will give this committee authoritative briefs covering these two fields.

There is one final point I want to make briefly. The percentage of the GNP used for scientific activities is often cited as a measure of the relative competence of different countries in research. Such gross rates should be used carefully. Gross rates give some useful broad comparisons, but in developed countries they can be deceptive. What we must have is the rate of expenditure in specific fields. For instance the United States spends perhaps four times as much as Canada does, measured as a percentage of the gross national product, but in the United States about 90 per cent comes through defence, atomic energy, and space budgets.

Canada's expenditure in these fields is far less, perhaps only 40 per cent. So, when we talk about the relatively greater amount the United States Government is spending on research we must break the statistics down a bit to get a clearer picture. For instance, when we consider the Government support to private American industries it is enlightening to note that 95 per cent of the money goes to industries making aircraft, missiles, and electronics, while the pulp and paper industry receives only one-half of one per cent. We should concentrate on our needs and stop talking about gross percentages of other countries, as our expenditures in research and development for strictly civilian areas are comparable. If we increase our expenditures 100 per cent and devote the increase to civilian ends, there is a real opportunity to aid the competitive position of our industry which is so badly needed. When we consider increasing our research budgets by 100 per cent, we must think of qualified researchers, not dollars, in fixing a timetable. The worst thing to do is to provide more money than can be effectively used. There are only two kinds of research—good and bad. Good research requires good scientists. The amount of money granted should be sufficient to meet the needs of the available number of good research men. Our present objective should be to "double our research, but in steps," as good men and facilities become available.

The Chairman: Thank you very much, Dr. Mackenzie, for this most stimulating presentation, and for telling us of your experience throughout those years, and for giving us this historical background. I am sure that the members of the committee will now wish to ask you many questions.

Senator McCutcheon: To start with, Mr. Chairman, I assume that we will be supplied with copies of Dr. Mackenzie's report, and the appendices.

The Chairman: I think Senator McCutcheon is referring to the report leading to the creation of the Scientific Secretariat.

Dr. Mackenzie: My report to the Prime Minister's Office is available.

Senator Bourget: Dr. Mackenzie, I do not know whether I understood you well, but you said that $155 million is being spent in Canadian industry. Do you mean that this entire amount of $155 million is money spent by Canadians themselves, or is part of it paid by some other country such as the United States?

Dr. Mackenzie: No, the industries in Canada spent this in 1963 out of their ordinary budgets as part of operating expenses. The information, Senator Bourget, is contained in the 1965 report of the Dominion Bureau of Statistics.

The Chairman: I think we have that. We must have these recent reports somewhere.

Senator Bourget: We were supplied with so much literature that—

Dr. Mackenzie: Yes; you as an engineer will be surprised. I cited this the other day, and some would not believe it. But I went back to look at the D.B.S. report this morning and found that it is correct.

Senator MacKenzie: Would that include money spent by American subsidiaries?

Dr. Mackenzie: Yes, but I did not include in that amount the moneys spent in the United States for purchase of research results.

The Chairman: But that figure would include the money spent by those subsidiaries in Canada?

Dr. Mackenzie: Yes, I put in only the money actually spent in Canada in their own laboratories, and on contracts with universities, et cetera.

The Chairman: But this total amount spent by private industry would include quite a share which is partly, directly or indirectly, subsidized by the Government, either through tax incentives or other methods.

Dr. Mackenzie: Yes.

Senator McCutcheon: Some of it would be subsidized through the tax incentives.

Dr. Mackenzie: These details appear in the 1965 report of the Dominion Bureau of Statistics. I do not want to be bound by precise figures, Mr. Chairman, because I am trying to illustrate. I am not trying to prove anything mathematical.

Senator MacKenzie: As an illustration, Canadair in Montreal are doing a certain amount of work in the field of aeronautics, aeronautical research and aircraft building. They are in some senses a subsidiary of American companies.

Dr. Mackenzie: In a very real sense, I believe.

Senator MacKenzie: Would the money they spend on research in Montreal be included in these figures?

The Chairman: Oh, yes.

Senator MacKenzie: That is what I thought, but I just wanted to be sure.

Senator Grosart: Dr. Mackenzie you used the phrase "Victorian type of government apparatus" trying to cope with this revolution. I was not sure to what period you were referring.

The Chairman: 1957!

Dr. Mackenzie: I do not want to be tied down to precise definitions. In the Victorian era governments had not envisaged technological scientific development as a factor in government at all so the ordinary government machinery was not geared for it, nor was it set up to handle such things as Polymer and T.C.A. Therefore, when I refered to that period I was suggesting that in the history of our government, its operating structure has had to be modified to meet new circumstances.

Senator Grosart: Can a representative parliamentary system of government cope with this problem in the future?

Dr. Mackenzie: I believe we must make it cope, otherwise we go to dictatorship. This is a danger.

Senator Grosart: How do you see it coping?

Dr. Mackenzie: Well, I have confidence in the future. My experience over the years has been that generally speaking there is no such thing as a complete collapse, I believe the general reaction of the people of a country eventually gives us the right answer, although a lot of damage may be done in the meantime. But my experience over the years has been that the final solution has been a pragmatic solution in the best interest of everybody. I believe in good will, you see. I think that ultimately people are activated by good will.

Senator Grosart: I am very glad to hear that that is part of the wisdom of your experience.

Dr. Mackenzie: Well, it is my own personal philosophy.

Senator Sullivan: Dr. Mackenzie made a most interesting statement when he said that medical research is completely divorced from all other kinds of research. We will have an opportunity to enlarge on that later. I happen to be a doctor and I do feel that that is most important.

Dr. Mackenzie: I do not want to be misunderstood. I had a lot to do with medical research and the Medical Council, as you know. When Sir Frederick Banting as a member of the N.R.C. organized the first Associate Committee on Medical Research I became interested and followed the development over the years. I would like to add that when the war came along some of the best work qualitatively was done by the three associated medical committees on defence research. Sir Frederick Banting started the work on aviation medical problems even before war broke out. In my opinion the quality of medical scientific work in Canada is very good on any standard of comparison. When we ask how much should be spent on medical research I do not think it possible to get a mathematical answer. It comes down again to national priorities, researchers available and objective judgment. All I can say is that no matter what total moneys are available, the medical profession will still have priority problems as between clinical and laboratory sciences, etc.

Senator Sullivan: Also biomedical science.

Senator Lang: Dr. Mackenzie, you said that there are two kinds of research, good and bad. I was wondering if you could give us a qualitative judgment of industrial research in Canada today.

Dr. Mackenzie: This is one of those generalized questions. I do not know how one would make a general judgment on industrial research. There are certain places where absolutely first-rate research is going on. If you refer to the quality of work done in first-class research groups in industry where there is, say, a staff of 100 people, I think one would find as good research as would be found in similar groups in the United States. In my view one of the differences between the results of United States and Canadian research lies in the daring and venturesomeness of top management in American research. There they can afford to gamble. If one has 20 factories one can afford to make one a research factory in which losing money is not fatal. On the other hand, if all your money is tied up in one factory you cannot do that.

If we are talking about the quality of trained men in Canada and other countries, I think it is true that they would be interchangeable. A first-class Ph. D. in Canada can exchange with a first-class Ph.D. in the United States, and no one would know the difference. I am ruling out, of course, the geniuses. Geniuses are rare.

Senator Carter: Do I understand you correctly, Dr. Mackenzie, that there is a great deal more money spent on industrial research in Canada than is generally supposed? I should like to get your opinion on two matters. Is this money being concentrated in specific areas or is it being spread over a very wide field, perhaps a little too widely to be effective? Secondly, should Canadian research be concentrated mainly on specific Canadian policy?

Dr. Mackenzie: These are important but awfully difficult questions that you ask. They are questions that cannot be answered on general principles. A decision must be taken on specific cases. For instance, if one were developing an industry in Canada and had, say, $1 million to spend on research, would you divide it up into 20 little laboratories of five or six people and expect to get anything out of it? You would not. You would concentrate. In war or other crises, when an immediate answer is urgent, the question would be: where and how can the best results be obtained in the shortest time? This nearly always means concentration in areas where there are resources in science and industry. On the other hand, my personal preference is to spread scientific institutions around the provinces where local advantages do not result in too great a degree of technical inefficiency. During the war the Research Council established many laboratories across the country for special reasons and most of them became permanent centres of research.

This question of balancing the excellence associated with concentration versus the value to local communities of spreading our facilities arises also in the locating of university graduate facilities, art, music, and medical research centres.

Senator McCutcheon: We will get Medicare to deal with that!

Senator Sullivan: Do not talk to me about that.

Senator Carter: Should we concentrate on specific Canadian problems like communications?

Dr. Mackenzie: The answer is not a simple yes or no. I do not exclude small researches, where a small group of scientists wish to do something. But multi-million dollar projects, such as space research and atomic energy, are usually not exclusively Canadian problems, although certain locations in Canada may offer special advantages.

Senator Carter: Canada is in a unique position to carry out research on communications over very wide spaces, in the north Arctic areas, where Russia has done much more in research than we have done. Should we not do those things which come naturally?

Dr. Mackenzie: Yes, that is certainly what we should do and I think in the main that is what we have done. As an example, the aeronautic industry and radio industry were stimulated by the problems raised in opening up the northern regions of western Canada. The only effective transportation was by aeroplane and there had to be a different type of aeroplane and a special navigation system, and out of the work done after World War I on northern development came the cathode ray detection finder, which was the forerunner of radar. The excellent research done on the upper atmosphere in Saskatoon is due to the fact that they have the magnetic pole in their back yard.

Senator MacKenzie: What is your opinion about research done in provincial laboratories such as in the Ontario Research Foundation? How does that fit into the picture?

Dr. Mackenzie: May I answer that not in the present but in the past? I faced this problem in the postwar period. In 1945 the Federal Department of Reconstruction, to assist smaller industries, started a Technical Information Service with field offices in all the provinces to make contact with the industries. This service was successful. After a few years certain of the provinces which had research foundations wished to take over the actual field work in their areas, and the National Research Council agreed to co-operate and made grants to these provincial bodies.

Personally I favour this type of co-operation. Obviously the federal Government has large central information facilities which provinces cannot match, but in my opinion there is an advantage in having provincial bodies make the contact with individual industries, if they so wish.

Senator MacKenzie: In reference to Senator Carter's point about the Observatory, there are some authorities who suggest this work could be better done elsewhere, where there is fine equipment. The question is: do we do such research on an international basis or should we be firmly national about it and try to keep the facilities and the scientists here?

Dr. Mackenzie: Your question raises two points, one of which I have answered. I have suggested broad policy should be made before, not after, governments have made grants, for it is difficult to pull out later. Secondly, there is no reason why we should not take part in international efforts if it is to our advantage, although I do not see much scientific advantage to us in taking part in an international project in Europe, such as that in atomic energy which has advantages for Britain and the common market countries. On the other hand, I think international co-operation on this continent on such things as space, meteorology, communications, astronomy and atomic energy would be useful. One cannot give a generalized answer yes or no on this question. One must decide on specific cases.

Senator Grosart: Dr. Mackenzie, you have related the great strides everywhere in our own and other scientific technologies to periods of two great wars. Yet today we very often hear it said that high level of defence spending in the world involves the sacrifice of other more important social priorities. Is there a contradiction here?

Dr. Mackenzie: The experiences in wars demonstrated the potential power of scientific application. The public became convinced that the application could do the same for peaceful purposes, not by spending moneys on military research but by using similar efforts in the civilian field. Many of the results of military researches do "spill over" to civil fields, but in my view this is not a good reason for undertaking military research work. I am afraid, however, few governments would spend the enormous sums of money on civilian research that they feel is imperative for current wars.

Senator Grosart: How would you meet such needs or form a rationale of expenditures?

Dr. Mackenzie: This is a very difficult question. As we all know when we are fighting for our lives normal thought goes out the window. I am afraid we are getting into a field I should not talk about, because it really is a current matter of broad political policy.

Senator Grosart: I do not know of anyone better qualified to discuss that than you are, sir.

Senator Desruisseaux: I have rather a brief question. We are often compared to the other countries as to expenditures of research, and we have been informed that some countries spend so much more than others. One example is Sweden. Do these expenditures in all cases include the military?

Dr. Mackenzie: I cannot answer that offhand, but certainly our expenditures do, as do those of the United States, England, and France. I do not know the situation in Sweden, but I feel sure that theirs do too.

Senator Desruisseaux: Concerning this discrepancy that we are supposed to have in the expenditure for military purposes, in all humility, would you like to comment on what we have achieved so far by way of research in comparison to other countries? Are we satisfied?

Senator Sullivan: For example, the Defence Research Board.

Dr. Mackenzie: If we go back to 1939 you will note we were doing little military research then. From the standpoint of military scientific development, the United States, England, France and Japan were relatively advanced. All countries increased such activities during the war. Canada, starting from nothing in 1939, came out of the war with a respectable world standing in certain military fields and in the technical competence of its industries. As you know, in the post-war years Canada became recognized as a first-class industrial and trading nation.

Senator Desruisseaux: If we were to go into 50 per cent and 100 per cent more expenditure in research, do you feel that we have presently the men to handle this?

Dr. Mackenzie: Not available at the moment.

Senator Desruisseaux: I ask that because you seem to consider it important.

Dr. Mackenzie: We have no sizeable pool of unemployed scientists. Qualified research scientists can not be made in a day.

Senator Desruisseaux: Are these being formed now, doctor?

Dr. Mackenzie: Oh, yes.

The Chairman: Through the scholarship scheme.

Dr. Mackenzie: Look at the numbers of Ph.D.s we are turning out: a thousand a year. I do not like to be complacent, but I do say that we have no greater problem than any other country in providing a future supply of trained scientists.

Senator Carter: Dr. Mackenzie, if we could increase our research expenditures by 50 per cent over a five- or ten-year period, where would you recommend that this extra money be spent? What areas of research are perhaps not getting as much attention as they should?

Dr. Mackenzie: This is the sort of long-term policy that your committee should be considering, as there is no reliable instant answer. Also, any answer given today might not be appropriate in five years' time. I do not know the answer but I am interested in the question and feel sure it is one that should receive intensive and continuous attention.

Senator Carter: I just want to get your ideas of what areas you think are being neglected.

Dr. Mackenzie: I cannot do that right now.

Senator Sullivan: Mr. Chairman, reverting to the question Senator Desruisseaux asked Dr. Mackenzie about military research, would you not say, Dr. Mackenzie, that the contribution of the Defence Research Board, plus all aspects of defence and medical research, has been one of the outstanding contributions in Canada?

Dr. Mackenzie: Yes, their contributions are more allied to civil activities than in many other countries. I think this is true and has been a tradition in Canada. As I have said, the medical research in war was first class. The medical groups have an advantage in moving back and forth between civilian and military activities, for actually their main objectives—the health and physical and mental well-being of others—do not change.

Senator Sullivan: I am intimately connected with it. That is why I made that statement.

Dr. Mackenzie: You feel as I do, do you not, that this is the situation?

Senator MacKenzie: Mr. Chairman, my next question is, in a sense, a loaded question like the other one was. It may be embarrassing. If so, Dr. Mackenzie does not need to answer it. However, I do not think that Canada has spent much money on research in automobiles, or the production of automobiles. Most of that work has been left to the United States and more recently to various of the European countries. Now, has this, by and large, been a good international division of labour or are there conditions in Canada which would justify our going in and spending some money on this kind of research? For example, we have done a little in aeronautical or aviation research.

Dr. Mackenzie: I think the trouble, when we get into the fields of automobiles and aviation, is that it does not seem practicable to design and build either automobiles or airplanes in Canada with any hope that we can compete economically with mass production in the United States.

Senator MacKenzie: Except for the Beaver?

Dr. Mackenzie: Yes, but that is a special case of a successful plane designed for special service and serving a relatively small market. As far as automobiles are concerned the economic difference between mass production and tailor-made production is the controlling factor. I do not think any prudent investor in 1968 would undertake to design and build purely Canadian automobiles, as there really is no great market for automobiles to meet special Canadian conditions that are not found in the western and mountain regions in the United States.

Senator MacKenzie: Are there areas where the international division of labour makes sense?

Dr. Mackenzie: I think so.

The Chairman: Dr. Mackenzie, as you were giving us the historical background of the development of our institutions in the field of scientific research, you started by saying that the N.R.C. had been, at the beginning, the nucleus with relatively wide powers to do research and to advise the Government on research and research policies. It seems to me, however, that especially after the Second World War, our research effort began to be more diffused and that the N.R.C. stopped being the centre of that activity. We have now seen various departments getting into research for one reason or another, so that now I think we have over 35 different agencies within the federal Government doing research in the field of the life and physical sciences. How do you appraise this kind of trend?

Dr. Mackenzie: I think it is very simple. I referred earlier to the N.R.C. Act of 1916 which set up the N.R.C. and gave it general responsibilities which governments over the years have made inoperative. The act was based on the principle that there should be two types of scientific effort in Government, one serving the general needs of the country the other serving the special responsibilities of Government departments having a scientific content.

The Chairman: At the level of what we usually call development programs? You referred to the N.R.C. Act.

Dr. Mackenzie: Yes. The departmental scientific units were to serve the departmental development programs. The broad non-departmental areas of science were assigned to the National Research Council. In England where the Research Council type of agency originated, the principle of division of effort is still enforced and they have now several Research Councils; that is, Agricultural Research Council, Resources Research Council, Medical Research Council, etc., which are free from any departmental control. In Canada this principle underlying the N.R.C. Act of 1916 was unconsciously nullified by Government action in accepting items in departmental budgets that led to building up in department scientific units a research council type. Take, for example, the Department of Agriculture. There you have a large group of first-class scientists doing excellent work that in England would be assigned to their Agricultural Research Council. The same thing has happened in other activities such as metallurgy, astronomy, forestry, fisheries, et cetera. The result is that the National Research Council, whose Act gave that body special responsibility for advising the Government, found themselves in a position where that responsibility had been nullified in practice by successive governments without relevant changes in the N.R.C. Act. Being a pragmatic sort of person, I do not think we can now say "That was wrong and we must back up." I think we have to say, "This is the way it has developed. The actual work has been good and co-operation between the scientists good, so we should now review the situation and find some workable form of formal operation."

The suggestions for setting up a scientific secretariat and science council contained in my report to the Prime Minister of January, 1964, was my suggestion for a possible solution to the problem just outlined.

The Chairman: Do you think we have the same flexibility in terms of recruitment when scientific research is done in Government departments?

Dr. Mackenzie: It is my opinion that the success of the National Research Council in demonstrating that the atmosphere and flexibility, found in research council organizations, does make for efficiency, has had over the years an influence in bringing better conditions and more flexibility into treatment of scientists in many government departments. I believe the situation is far better than it was 20 years ago, but I still feel that normal departmental procedures will always prevent the kind of flexibility found in research councils.

The Chairman: Do you think the work of all these agencies as they are working now can be effectively co-ordinated?

Dr. Mackenzie: Yes, I think they can. But it will require strength to do it. It is like reorganizing anything else; it cannot be done by prayer. Vested rights and old prejudices are often involved. Nevertheless, I think it can be done.

Senator Yuzyk: We do have a Science Council in Canada, do we not?

The Chairman: Yes, it will be making representations tomorrow.

Senator Yuzyk: Could I ask Dr. Mackenzie here how optimistic he is about the work and the role of the Science Council, in general?

Dr. Mackenzie: With regard to that organization, which has only been set up for a year or a year and a half, I think it is too early to make a judgment of any value. There are bound to be early organizational problems, but I am not pessimistic about long-range results.

Senator Yuzyk: Are we in a position in Canada to learn about the research work that is carried on in other countries, so that we would not necessarily have to duplicate some of that work?

Dr. Mackenzie: In my view we are very well informed on what is going on in other countries. There are few days in a year when there are not numbers of Canadian scientists attending scientific meetings in other countries of the world, and Canada receives similar numbers of visitors to her laboratories. We also have liaison offices in the United States, England and France, and our scientific libraries have the important publications from all developed countries.

Senator Yuzyk: I mean in the broad sense, do we bring this all into focus in some body in Canada?

Dr. Mackenzie: Knowledge is of two kinds, written and personal. The written knowledge is available in our well-integrated library systems. The most valuable knowledge comes from personal contacts between working scientists, and this cannot be centralized. For instance, if knowledge were wanted on medical sciences, the Medical Research Council can provide both literature and people with specialized knowledge. The National Research Council could do likewise in all its various fields of activity, and so on. While all this information cannot be located in one body, it is quite possible and I believe essential that there be one central body that knows where and how to get all information.

The Chairman: Is it not also a function of the Science Secretariat?

Dr. Mackenzie: Yes, that is so. I would like to emphasize that interchange of current knowledge, before publication, comes from personal contact between scientists who know the work of each other.

Between well-qualified scientists there are no internal scientific borders, except perhaps in secret military establishments. Any idea that we are sitting isolated in Canada and do not know what is going on in the world is incorrect. We are well informed about science in other countries.

Senator Yuzyk: Then there is every reason for us to be optimistic, as I have asked of you?

Dr. Mackenzie: Yes.

Senator Yuzyk: You are optimistic; so we can be too.

Dr. Mackenzie: Optimistic but not complacent.

The Chairman: But there is always room for improvement.

Thank you very much indeed on behalf of the committee, Dr. Mackenzie.

The committee adjourned.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Wednesday, March 13, 1968.

The Special Committee on Science Policy met this day at 9.45 a.m.

Senator Maurice Lamontagne *(Chairman)* in the Chair.

The Chairman: Honourable senators, we are about to start our second day. We have the pleasure to receive this morning Dr. O. M. Solandt, Chairman of the Science Council of Canada. I do not have to introduce him to you, as most of you know him.

If Dr. C. J. Mackenzie, whom we had the pleasure to see and interview yesterday, is the grandfather of scientific development in Canada, perhaps Dr. Solandt might be described as the father, or the son, as he always has been very interested in these questions which are basic to our investigation.

We have pleasure also in having Dr. H. E. Petch, the Vice-President in charge of academic programs and research at the University of Waterloo, which is a very fast growing institution. Dr. Petch may have something to say later about the research programs of that highly progressive university.

Unfortunately Dr. Gauvin has become lost somewhere, perhaps because of the storm, so we will proceed without him. I am sure that he will arrive in due course.

Senator Bourget: This is a good committee to find him, by means of research.

The Chairman: Dr. Solandt has no prepared text, but he wishes to speak to us at length on those problems which are of interest to him and to us. After that, we will have the usual question period. Dr. Solandt.

Dr. O. M. Solandt, Chairman, Science Council of Canada: Thank you very much, Mr. Chairman. Honourable senators, I would like to say, first, how honoured I am to be invited to appear here. The Science Council as a group, and myself personally, are tremendously interested in the formation of the committee. We are very anxious to see that it should succeed in its work and we are most willing to help in any way that we can.

I feel that I should begin by giving you Dr. Roger Gaudry's apologies for not being present. He is Rector of the University of Montreal and Vice-Chairman of the Science council, and has been very active in its work.

Dr. R. Weir, the Director of the Science Secretariat, would also have been here today, I am sure, because the Secretariat is the staff of the Science Council.

However, both these gentlemen are in Paris today at the OECD ministerial meeting and will not be back until tomorrow; so I present their apologies for their absence.

In deciding on the presentation, we debated whether the whole Science Council would descend on you but we decided that probably would not be a wise idea. It was suggested that Dr. Petch would come, and he is here. He represents the academic side of the scientific community, as the vice-president, academic, of the University of Waterloo. I hope that Dr. Gauvin will appear soon. He is manager of the Noranda Research Centre in Pointe Claire, so he represents the industrial side.

As you probably know, the Science Council was planned to have about equal representation of government, universities and industry on it. I deliberately did not invite any of the Government representatives, because you will be hearing almost every one of them as the representative of his own particular interest in the Government.

I should apologize in advance that I did not plan the presentation so that either Dr. Petch or Dr. Gauvin would make an independent initial presentation; but I hope they will become actively involved in the discussion and if, after I have finished, Dr. Petch feels urged to make a statement, I am sure you would welcome it, and so would I.

Honourable senators, I should begin with particular emphasis on the fact that the

Science Council warmly welcomes the formation of this committee. We have begun to see that one of the major problems which the Council will face is the coupling of its recommendations with the political action in the Government. There is no use in the Science Council making representations, if nothing happens. There is also no reason why political leaders should accept the advice of the Science Council, if they do not understand it.

It seems to me that the work of this committee will be a major step towards achieving a broader knowledge, amongst political leaders, of what the scientific community thinks should be done; and, consequently, a better understanding in that respect.

I hope that this will be the beginning of a continuing outlook. I feel strongly—and I gather that Dr. MacKenzie expressed the same views—that this committee might become a permanent one. The needs of science in Canada will be changing continually and changing quite rapidly in the foreseeable future. It will not be possible to come to a solution of our difficulties and say "If you do this, it will solve our problems for the next ten years". We will be lucky if we find a solution for one or two years. Therefore I hope the committee will in some way take a continuing interest in science policy in Canada.

Mr. Chairman, I should have interjected earlier, in response to your kind remarks about Dr. MacKenzie being the grandfather of science and my possibly being the father, that if you notice similarities between our ideas, please do not assume that this is collusion. I did not hear what he said and he has no idea as to what I am going to say.

Over 22 years now we have discussed the problem of science policy in Canada at least once a month and probably more frequently. Therefore, although we do not agree in every detail we have at least threshed out a common understanding. For that reason, you will not find any fundamental difference in view between Dr. MacKenzie and myself. I should add that, as I think you all know, he really has made a tremendous contribution, not merely to running the National Research Council in Canada but to the whole evolution of the scientific community.

Honourable senators, I planned to give you today a very broad general presentation of the background of science policy in Canada. I will try to avoid details, I will not tell you anything in detail about the work of the Science Council or of the Secretariat. You have already some material on that and if there is any further information you would like I would be happy to appear again.

I hope that Dr. Gaudry will have an opportunity to appear. Dr. Weir will appear and I hope also that you will feel quite free to ask either the Council or the Secretariat to prepare special presentations on any subject in which you are interested.

Furthermore, I believe your staff should go carefully over all the material which the Council and the Secretariat have already collected. On discussing this point in the last few days, I find there is some detailed information in our possession which might be useful to you. We will ensure that you see it and have it all available. We do not wish to invade you with information, as you could easily become overwhelmed by its quantity. Nevertheless, we can probably save you both time and trouble by giving you some of the information which has been collected and some of the analysis of it.

I also will not go into the history of the evolution of science in Canada. I think this is most important to the understanding of where we are today, but I am sure you got a thorough analysis of that from Dr. MacKenzie yesterday, and, as I say, I am sure that the outlines he gave are very similar to the ones that I would give.

Before starting on the main discussion, I would like to begin by defining science. I think this is quite important. I do not pretend that my definition is the right one. All I want is to be sure that you understand what I mean by it. You do not have to accept it. I have found that there are, first, many definitions of science, and I have found that it is more useful in most discussions to limit the word "science" to mean: "man's accumulated and organized knowledge about himself and his world". The word science is often used to describe a process or operation or activity—that is, the collection of scientific knowledge; but, for reasons that I think you may see, it is more convenient and leads to less misunderstanding, if you use the term science primarily for this body of knowledge which man has accumulated.

I also think that it is very important to recognize that science in this sense includes both the natural sciences and the social sciences. I feel that the subdivision is an artificial one. It is a necessary one for organizational purposes, but conceptually we want to make sure that we do not build an artificial barrier between the natural sciences and engineering on the one hand and the social sciences on the other, because they are all part of man's knowledge about himself and his world, and we are in real danger of separating our knowledge about the world from our knowledge about ourselves. Part of our troubles in the world today arise out of this.

Arising from this definition of science, there is growing up in the world today a new branch of science which is called "The science of science." When you think of it in this way, you can see that this is quite logical. This is trying to accumulate knowledge and to classify it about how man does in fact use what he knows about himself and his world. And this science of science, defined in this way, is clearly going to be one of the important studies in relation to science policy. It is really the investigation of science itself as a social phenomenon: how does it affect man and his world and his way of life?

I think you could, in fact, say that you on the committee here are students of the science of science, because you are not going to look into the details of what scientists are doing. Your concern is to find out what is the impact of science on our society. You, I am sure, will not want to look critically at whether the physicists in one university are doing better physics than the physicists in another university, but will rather be concerned with what is the importance of research for the use of physics in our modern society.

And so I think certainly the object of the Science Council—and I am sure it is your object—is to try to understand the impact of science on Canadian society and how we can best use science in the growth and development of the country.

As I see it, we are now just on the eve of a new era in the support and organization of science. As I am sure Dr. Mackenzie told you, in the past scientists just lobbied for the support that they wanted for science and they usually got that support, because up until now, and I think still, science has been a *Good Thing,* with capital letters, and also it has represented a relatively small part of the national budget. And so it has been supported relatively uncritically.

But now we have a completely new interest in science, and it is probably worth just briefly tracing the goals of this new interest in science. As I see it, it began really between the wars when industrial research in Great Britain, Germany and the United States first contributed so much to the economic growth of those countries. During the period between the wars people began to see that science and technology had a major impact on economic growth. Then, during the second war, we saw the tremendous contribution that science made to victory; radar, jet engines, the atomic bomb and so on. Here for the first time people began to see that science could actually solve specific problems, that you did not just have to let it wander and hope that it found something, but that it could set out to solve problems. Radar, for instance, arose in response to a specific need for long range detection of aircraft. The jet engine arose from a specific need for a lighter power plant, and so on.

Then, of course, after the war we had the growth of nuclear power based upon the wartime work on atomic bombs. More recently we have had the impact of satellites and the space race.

So, nowadays, everyone is beginning to see that science is a vital national activity, not just a hobby for scientists, and that it contributes essentially to defence and to economic growth and that more recently, as we are beginning to see, it can contribute to the solution of social problems.

But as we see it increasing in importance in our society we are also beginning to see that it is going to be very costly, that it does, and will in fact, represent a quite important part of the national expenditure. This means that it now comes into direct competition with other objectives of expenditure, not only of money but of our rare resources of skilled people. And as soon as it becomes a major economic factor, where we have to make important national choices in the use of our resources, then to my mind it becomes a political problem. In some ways the most important thing that is happening now is that science policy, which used to be something that a few scientists discussed quietly, has now become a major national problem and one that will be of continuing and growing importance in our political life.

So, as I see it, the situation that we are now in is that it is up to the scientific community to consider how science can serve the nation and to put forward these views to political leaders. Political leaders are already looking to science to help. I think they are sensitive to the idea that science can do more for the nation that it is doing now. In fact, the very formation of this committee is evidence of that. And then the claims of science must be put forward and evaluated on both scientific and political grounds, and out of these successive evaluations national science policy will evolve.

If you view science policy as growing in this way, then it is obvious that scientific policy in each nation will be unique, because the policy arises out of an interaction of what science can offer and the peculiar national problems of each individual nation, and so we cannot look to any country to evolve a science policy that is suitable to Canada. We have to grow our own out of this interaction between the possibilities of science and the needs of the nation.

Here I want to emphasize that both scientists and politicians are very new in this game. We in Canada are perhaps a little newer than others, but every time I get depressed about the progress of our science policies in Canada I go and read some of the literature about the progress of some of the science policies in Europe or in the United States and I feel we are not really so badly off. Everyone is experimenting and struggling in this new and difficult but very important field.

Let us see in a very broad way why any nation should support science. It seems to me that the reasons for supporting science can be divided into three broad categories. First of all there are the cultural reasons. I want to emphasize this, because much of what I have to say later emphasizes the importance of science in social and economic problems, and we must not lose sight of the importance of science as a cultural activity. There are many people—and naturally they are mostly scientists—who say that science represents man's greatest intellectual achievement, that it is the very pinnacle of our activity. Some of them go so far as to say that the modern large accelerator, for instance, is the contemporary equivalent of the great cathedrals of England. I would not go that far, but I think we have to recognize that if we are to be a leading community and a leading nation culturally, we must not only cultivate arts and the humanities but we must also cultivate science, particularly pure science or what I like to call curiosity-directed research—the term "basic research" now means so many things. What we are talking about here is science directed by the curiosity of some gifted individual which has no immediate aim. Also in the same category is the support of the studies and history of the philosophy of science and particularly if it is to relate science to the modern world.

The second broad reason for supporting science is economic, and here I do not need to go into details. We all know that research leads to new products, new processes, better management and finally to those innovations which increase productivity. These add greatly to economic growth and in the long run to the general standard of living in a country. I will come back to that in more detail later.

The third group, and one which I think has received far too little attention in the past, is the application of science to the solution of the social problems of our nation. Here, I think, we may look at social problems in a very broad setting. I like to think of the idea of human ecology. I am sure most of you are familiar with the word "ecology," which means very broadly the relationship of man to his entire environment or rather the interaction of man with his environment. We need far more people studying ecology and applying every principle of science, social sciences as well as natural sciences, to find out the best way of adapting our environment to human needs.

This, of course, is principally a problem in our cities since we are an urban society and already we are becoming more urbanized. As we become more urbanized our cities are barely keeping pace with the growing problems of transportation, communication, waste removal, and so on, much less the social problems of making the city a satisfactory place in which to live, particularly for the poor. There is no need here to underline the urgency of this problem in Canada. We have seen the difficulties that the United States is getting into, and I think sociologists there are beginning to see more and more clearly that a lot of trouble is due to the fact that the city is a very unsuitable environment especially for poor people whether black or white. We have a little time before we will be faced with the same problems as the United States, so we ought to start putting some effort into this. We see these three broad national reasons for the support of science.

Now, how does science actually work in our society? Here I would like to emphasize that I have been talking about science and not about research. I would again like to emphasize that the Science Council is not a research council and what we have been talking about is not a research policy but a science policy. The problem of doing research, which advances the growing edge of knowledge, is a very important one. The amount of research done in a nation is a pretty good I would again like to emphasize that the Science Council is not a research council and what we have been talking about is not a research policy but a science policy. The problem of doing research, which advances the growing edge of knowledge, is a very important one. The amount of research done in a nation is a pretty good measure of its scientific activity. But the idea that we can accumulate through our own work the vast knowledge resulting from the work going on all over the world would be very foolish.

We must talk about the use of science and research as one of the elements in a science policy. Through science working in the community and in our society we have come to know our scientific community, and this is not just those people who do research but includes all the people who use science as the principal stock in trade of their daily work. It begins most importantly in our schools and if we do not have good scientific teaching in our schools then we won't be able to use science intelligently because we won't have good scientists.We must also have it in our universities where it includes not just research but the teaching of science. Again in government the scientific community does not include just people in research institutions; it includes many people who are using their science in daily life and who could not do their jobs well if they were not good scientists. The same is true of industry where again the scientific communities are, or so I like to think, probably the second most important element in industry. The most important element is probably the aggressive manager or entrepreneur. But modern industry particularly, the technologically-based industry, cannot be successful unless it has good scientific, mechanical and engineering support throughout the organization. Again it is not just research and development; it must include good management and all the modern management sciences and all the aids to management. This includes good science in production, marketing and right through to use.

So much for a background of what science is, as I see it, and how it pervades the nation.

Let us talk for a minute about what science policy is. As I see it, science policy is a broad strategy for the use of science by the entire scientific community in support of the national goals. These goals are economic and social. So our definition of a science policy involves first of all defined national goals, and this is a terribly difficult subject. I think it is one that we should give more attention and more time to. It involves the study of ways that science can contribute toward the attainment of these national goals, and then allocating resources to science to do this work. Here, as I have mentioned before, this becomes a competition, because there are many things that contribute towards the attainment of our national goals other than science, and the genius of the politician is to allocate the resources correctly among these various claims.

Then we come to the allocation of the resources that are given to science, at the political level, to the various scientific applications. Here this becomes partly a political and partly a scientific job, because the scientists have to make an important contribution at all levels in these policy decisions.

One thing we have to remember particularly in deciding on national goals for science is that, as some famous scientist said, "scientific research particularly is the art of the soluble." If you look at the history of the growth of science, it consists of a series of discoveries which are made at a time when the general state of science has advanced to the point where it appears possible to reach a solution, and good scientists can usually tell you whether it is worth putting money into a particular area or not.

To take a ridiculous example, we might say that the most important thing in science for Canada would be to discover perpetual motion, but if you consulted most serious scientists they would say that it was a great idea but they did not see any feasible way of attacking it, that they had no ideas on how to go about it, and that it would be better to drop it.

We have to recognize this kind of interaction going on all the time. We see it occasionally in the United States, where Congress will decide to give more money, say, to research on cancer than scientists have asked for because Congress thinks it is terribly important. But scientists have only so many ideas as to how to tackle a problem, and as long as all the good scientists are supported in pursuing all the good ideas they have, more money is just a waste of time. So, money is not always the determinant in how fast we can go in science.

All these requirements for science policy I have outlined so far are common to any country. They are not peculiar to Canada, but we have in Canada some special requirements that we have to consider in formulating a science policy.

Probably the first of these is the need to specialize. Every country has a need to specialize in science, even the United States and Russia; but, obviously, in Canada we have it more acutely than most because we are a highly industrialized country and very large geographically. Our scientific needs are really almost as broad as those of the U.S., except that we have far less need for defence and space expenditures. In other fields we would like to do everything they are doing, but we cannot. Here we run into one of the real dilemmas in science policy in Canada, and I think the one that will require the greatest skill in management, because we have two conflicting needs.

First of all, as a small country it makes sense for us to try to use the results of research in other countries just as much as we can, because the U.S. does 10 or 15 times as much research as we do, and many other countries do more than we do. It is good research and much relates to our needs. We know, from long experience, that we do not use research in other countries effectively unless we have some research in the same field going on in Canada.

So, on the one hand, we have this need to do research in many fields in Canada, as a coupling device in order to ensure that we have access to the resources of the other countries. On the other hand, it is quite clear that research and the use of science will contribute more to Canada if we become leaders in certain fields. And, as I see it, all we need to do is to have a broad base to couple us to the world scientific community and some narrow peaks of excellence where we are world leaders, and these peaks have to be in connection with unique Canadian needs or capabilities.

I will not go into the detail of the criteria here, but obviously we have unique requirements arising out of climate, out of geography, out of some of our social backgrounds and problems. High on the list of unique Canadian resources for supporting science we must put capabilities, because in areas where we have especially able people who have shown themselves to be leaders in the world, we should make sure we give them support. I think this problem of specialization may be one you will want to discuss further.

We also have in Canada, not a unique problem but an unusual problem, that of arriving at the optimum distribution of our support for sciences among the different sectors of the scientific community.

I have mentioned that we have the universities, government, and industry as the three main sectors. Traditionally, in most developing countries the government naturally has to take the lead in building up research. Dr. Mackenzie outlined to you yesterday the excellent way in which the Government, particularly the federal Government, has led in the growth of science in Canada. But, as a country gets larger there is every reason to believe that this dominance by government ceases to be a good thing, and that there should be a wider distribution of activity into the universities and particularly into industry. We are just at that transitional point now. If you look at what has happened in the last three or four years, you will see that this change is happening. Incidentally, I feel this is one of the many ways in which Canada can help developing countries. We can advise them as to how to support their science and achieve this change-over from government control to a wider base of activity, and in achieving this optimum distribution in Canada now I think there are some obvious principles that are to be considered.

Excuse me, but I have just been handed a note, and I may say that this note says that Dr. Gauvin's plane could not land in Ottawa and has had to return to Montreal. So, he will not be here for the morning meeting. Science has failed!

The Chairman: Or the weather.

Dr. Solandt: As I was saying, I think there are a few broad principles that can guide us in this decision as to how to distribute scientific support among the different sectors of the scientific community. The first one is that basic research, fundamental research, has two products. One is new knowledge and the other is new scientists; and, consequently, in general, although there are obvious exceptions to this rule, basic research should be done in universities or close enough to them that graduate students can have access to it and profit from it.

Another lesson that I feel is very important, and it can be illustrated by many examples from Canadian experience, is that applied research should be done as close to the point of use as possible. I think this applies in every kind of scientific research.

Another thing is that I am sure that the broad social uses of science that I discussed very briefly must have their main base in government. They require long-term concerted action and will not prosper if their central guidance and control lies anywhere other than in the federal Government.

Then, we have in Canada another special problem that I feel we have not faced adequately, and this is the optimum geographical distribution of our efforts in science, and particularly in research. Here there is a definite conflict between the need to centralize, because scientists like to work in large groups—they find it stimulating and interesting, and, of course, it gives them better job opportunities, and the fact that decentralization of research facilities throughout the nation can do a great deal to help in regional development, and in getting the support of the scientific community.

When I was chairman of the Defence Research Board, the Board deliberately set out on a policy of decentralization. They have laboratories from Halifax to Esquimalt, including a major one outside Quebec City. I am deeply convinced that this is a wise policy, and in planning future expenditures in Canada we have to think very carefully of this balance. I do not mean by this that everything must be decentralized without thought, but we must weigh the benefits of centralization against the benefits of decentralization.

Senator McCutcheon: Even though that involves more money?

Dr. Solandt: Yes, even if it involves a little more money, and even if it involves a little less than the best situation from the point of view of the scientists.

Senator McCutcheon: The scientists will need to travel more.

Dr. Solandt: Yes, it will be slightly more costly, but I think it is a major factor in the formulation of intelligent national policy for science in Canada. We have got to see that these resources are distributed in the best way for the country.

So much for the sort of underlying principles in arriving at a science policy. The next thing is to go briefly into the kind of logical analysis one would go through in arriving at a policy. Clearly, the first thing is to ask, "Where are we now?" We have to answer that question because whatever policy we adopt has to start from where we are today. Fortunately, we are not like the man in the story—I have told it before, and you may have heard it—about a bewildered tourist in England who stopped to ask a local yokel how to get to London. After a long pause the man said, "Well, you know, if I were going to London, I wouldn't start from here."

I think we are very fortunate in Canada in that we are really starting from a good position. This is something that I would like to emphasize, that Canada has really done quite well in the application of science to national problems in the past. We have no reason to be ashamed of what we have done, but we have every reason to try to ensure that we do better in the future, and particularly that we are more flexible and that we adapt the use of science to changing events more quickly than we have done in the past, because the future is going to change even more rapidly than has the past.

I will not attempt to go into detail as to where we are today. The first thing that the Science Council did when it began work was to start a series of what we have come to call inventory studies, to try to find out exactly what is going on in research in Canada—in government, in universities, and in industry. Several of these studies are complete, and are available to you. Others are in progress, and we would be happy to give you what information we have, and to report the state of their progress.

Having decided where we are now obviously the next thing is to decide where we want to go, and to do this one has to define national goals. Obviously the definition of national goal is not a job just for scientists, although I think they should contribute to it. But, you cannot plan an intelligent national science policy unless you know what the national goals are, because as I see it the role of science is really to make a contribution, and I hope a major contribution, towards the achievement of these goals.

I will list what I think are some of the important national goals, without going into them at all. National unity is probably our most important and pressing goal. Then there are full employment; rising G.N.P. per capita; elimination of poverty, which carries with it the perfection of our various welfare system; improved education; improved health services; help for the Indians and Eskimos, who represent our special problem in this field; and a major contribution to world peace, both by defence and probably even more importantly through foreign aid.

These are just a few of what seem to me to be the more important national goals. There may be others that you would wish to add to this list.

The next thing is to know what resources we have available. Here I will not go into detail, but we have done some studies of the availability of trained manpower. This obviously is something to look at because, as I mentioned before, there is no use in asking for more money for science, and particularly research, if we have not got the people. So far as we can say, from a first look at the forecast of the production of natural scientists and engineers in Canada, we are likely to be fairly well off over the next ten years. The growth of the output of our universities is very substantial, and we are absorbing the output quite quickly. But, while there is every reason to believe that we will have enough, there may be very serious imbalances within the total.

One of the most worrying things is the fact that the output of engineers is not growing at all. It really has not changed over the last five or six years, so the percentage of students at universities who are taking engineering is dropping every year.

Senator Desruisseaux: Excuse me, Dr. Solandt, but would that be due to the immigration situation in respect of engineers?

The Chairman: Dr. Solandt is speaking about students.

Senator Desruisseaux: But the number of graduates of universities has been dropping off, and there has been a large number of engineers coming into Canada.

Dr. Solandt: It is hard to know just what the cause is, and its effect. Are Canadians not going into engineering because we are importing engineers, or are we importing engineers because we have not got enough of our own?

The Chairman: It may be also that other specializations are growing so fast. I am told, for instance, that the enrollment in the social sciences is increasing at a fantastic rate. That might also be an explanation.

Senator MacKenzie: Do you think it is the attractiveness of some of the other fields?

Dr. Solandt: Yes, I think so. As a matter of fact, as I note the statistics, this growth of the social sciences has not yet been as pronounced in Canada as it is in the United States. It is spectacular there. People have been switching from the natural sciences and engineering, as I recall, over the last several years. Psychology is the largest and fastest growing discipline in United States universities, yet our study of scientists in Canadian universities shows that we are not producing enough psychologists to staff the universities. Forty per cent of all our professors in Canada are Americans, and I do not mean people who are educated in the United States; these are people who were born and educated in the United States, and who come up here. I was going to go on to say that while the total available manpower in natural science and engineering will probably be adequate, but with some serious imbalances within the total, I am not nearly as optimistic about the social sciences at the present level. But I think they will increase rapidly.

Senator Sullivan: Dr. Solandt, did you say "psychologists" or "psychiatrists"?

Dr. Solandt: Psychologists.

Senator Sullivan: Thank you.

Dr. Solandt: We have a very interesting study on psychology in Canada, which was started by the Secretariat before the Council was formed, which you might be interested in seeing. It is not a very important study, but it is well done. It shows very lucidly the problem of supply and demand in a narrow field of this kind.

Our manpower problem will be serious. With our tremendous growth in education in general, we will have to train people to achieve the things we want. We will need a lot of guidance and influence to get the training in the right places and the right kind of training, but it will be there quantitatively.

The Chairman: Before you go on, have you observed any specific gaps, for instance in a whole class or group say, in engineering, in the universities? Have you been able to go into that?

Dr. Solandt: No. We have the studies on engineering in the universities under way now. In fact a committee is meeting this afternoon and we hope that out of this will come some analysis of the problems within engineering.

The other important resource besides manpower is money. Here of course we have a relatively wealthy country. We have an unfortunate and common tendency to spend more money than we have, both personally and nationally. Therefore, how much money we have for science is just a matter of priorities. This really is the crux of the problem —just how much money should be invested in science.

It is quite clear that it is a very paying investment in many ways and has a very real claim to a substantial part of our national resources. As I see it, our real problem is that the scientific community must make the case for more money for science. They must try to make clear what the nation can get if it spends more money on science. People such as yourselves have to make the decision between spending more money on science or more on other things.

The next problem is as to how we use the resources we have to achieve the goals that we have chosen. This is the problem which will occupy the Science Council and the Secretariat, among others, perpetually.

I thought that rather than give you a detailed analysis of how we achieve the goals, I might just give you some particular conclusions as to what we ought to do. I would emphasize that if these conclusions eventually prove to be wrong, you should regard them as personal conclusions. If they prove to be right, then please consider them as conclusions of the Science Council. They do not come with the authority of the Science Council at all but most of them naturally arise out of the discussions which have taken place at the Council.

The first conclusion is that our total expenditure on science and scientific research is less than the optimum amount. The evidence for this is not absolutely conclusive. We are always told that many other industrial nations are doing a great deal more research and development than we are and are growing faster than we are; but there are also nations spending less than we are spending and which are growing faster than we are. Therefore, we must examine this problem carefully and not say that the solution to our problem is more expenditure. We must look at each individual demand and weigh its value against competition from other demands on our resources.

I would very much deplore our saying "we are spending a little over one per cent of gross national product on research, let us spend two per cent." We should look at the various applications for money and decide each one on its merits. I personally have a firm conviction that when we do this it will result in rising expenditure on science in a general way, including research, and that we may even get two, three or four per cent of the G.N.P. in the next twenty years. But we should not arrive at it by setting ourselves a financial expenditure goal.

Within this need for more expenditure, obviously the universities need a continuing expansion of support for research, to keep pace with increased registration. If we are training more and more people in our universities, if we are going to maintain, much less improve, the quality, we must spend an increasing amount in research. We must do more research and development in Canadian industry. This represents one of the most challenging and difficult problems. We cannot argue some analogy with other nations in the field of industrial research, because our situation is very different from that of any other country, since we have a very high proportion of foreign ownership.

Most of the foreign-owned subsidiaries in Canada are subsidiaries of technologically active and alert companies in the United States, and of some in Europe. Therefore, most of Canadian industry is surprisingly competent technically, even where it does little on research and development in Canada. We know from experience in other fields that we will be better off if we do a fair amount of research and development right in Canada and in Canadian industry. I think most foreign owners are coming to see that it pays them to do research in their Canadian subsidiaries—but how much is a very important question. In effect, we are already paying a great deal for research done in foreign parent companies. In some cases, the payment is direct and can be seen and measured. In other cases it is indirect, because there is no charge made for the know-how at all.

One of the important things we must look at in Canada, in connection with science and industry, is the fragmentation of our industry brought about partly by foreign ownership.

Secondly, there is the fact that experience, both in Canada and in other countries, shows that research done in industry does not pay at all unless it is carried right through to production and use. We have a surprisingly bad record of continuity in this way. We tend to say that we are doing some excellent research and development, that we have produced a prototype of a gadget of some kind; but no one ever builds it, so the money is almost completely wasted. We must recognize that what we are concerned with in history is the process of innovation, not merely research and development and this process of innovation is not complete until the new product has been designed, built, and sold profitably. This process needs a lot of help from science—not just in the research laboratory but in good management, in good marketing, and in all the other details which go to the completion of the sale and use of the new product. Here again I would like to emphasize that science cannot do this by itself. It needs good entrepreneurs really pushing management.

Another of our problems in Canada is that we must examine and think of our research laboratories in the total community very clearly and try to ensure that in the future their growth fits in with this new idea of wide distribution of science through the nation. There is surprisingly little disagreement with this view. You will find it expressed when you come to hear the leaders of the various government laboratories. This concept of a gradual change in the role of the federal Government from being an agency that does research to being an agency which fosters, stimulates and guides research throughout the whole nation, is taking place now, and this is something we must encourage.

As I mentioned before, the so-called curiosity directed to research should be directed mainly to the universities. But that does not mean that government laboratories should not be allowed to do some of it. Government laboratories must be allowed to do some of the curiosity research in their particular fields. I think that research aimed at new products or processes should be as close as possible to the point of use. Usually in industry there have been some striking examples of research on new processes done in government laboratories which have not resulted in any profitable exploitation because they were not done closely enough to the point of use.

Another problem I would like to dwell on at a little length, because it is so important, is that in applied research of any kind, wherever it is done, whether it is in government, universities or in industry, the first test as to whether it is good research is whether it is relevant. That is, if you get the answer, is it going to solve some important problem, social or economic? Because, if it is not, then do not do it. We have in the past tended to carry over to applied research the criteria that are used or that are appropriate to basic research. That is, in the field of basic research the test is: is it first-class research? You do not particularly mind where it is going, because if you knew that you would not have to do it. It really would not be basic research. But the test is: is this first-class research? Will it stand up to international first-class competition? If it will, then let us support it. But this is meaningless in terms of applied research.

Applied research may be the finest in the world, but, if you get an answer that is no good to you, then forget it. Leave the answer to those who need it and let us confine ourselves to the area where we can see the need in Canada.

Then, finally, among the conclusions as to what we need to do in Canada, like every other nation and every other human activity, we suffer very much in the scientific community from institutional rigidity. I could regale you with horror stories about this related to government, industry and universities. I am not picking on any part of the scientific community. I know of nothing more rigid than the departmental organization of most of our universities.

An Hon. Senator: Hear, hear.

Dr. Solandt: So, if the universities start throwing stones at the Government, the Government can certainly throw them back. If you want stories of institutional rigidity in industry, they are easy to come by as well. One of the problems is to try not only to get the spirit of change but also to organize as flexible a system as possible so that we do not just decide, "Well, we have got a rigid set of institutions not quite suitable to the modern days. Let us set up more rigid institutions which will be good for tomorrow but which will not be good for the day after tomorrow."

Well, obviously, the next problem is how to guide the growth of science along the right lines to meet these needs that I have outlined. And we have been casting around in the Science Council and in the Secretariat for ways to do this. Obviously, we want to try to find a positive approach. There is no use going to people and saying, "Stop doing that. It does not accord with national policy." It is better to go to them and say, "Why don't you do this, which would be much more important, and this is why it would be much more important."

Also, there really is remarkably little going on in science today that we want to stop. Very little. What we want to do is guide the growth that we can see in the future along the right lines, and this is probably even more important in the social sciences than in the natural sciences.

One of the ways it looks to us to be very promising is to initiate a series of major programs. Now, the easiest way, probably, of understanding a major program, understanding the idea we have in mind that we are trying to describe by these words, is to look, for instance, at Atomic Energy of Canada or rather at the whole of Canada's activity in atomic power, which includes A.E.C.L., Atomic Energy Control Board and the N.R.C.—but it is centred in A.E.C.L. Here you see a program which includes basic research in the universities and a good deal of basic and applied research in Chalk River. In fact, the basic and applied research is all mission-oriented at Chalk River. There is also applied research and development in industry and production in industry and use of research in sales in industry. So here you have a program instituted in such a way that it crosses both government and industry.

We have visualized the possibility of starting the same sort of major programs in other selected areas. I would just name the areas we have been talking about. Space. The Science Council already made a recommendation that we should start a space program in Canada. We already have a lot of work going on in space. I think you would all be interested to know that when I was speaking in Washington a few weeks ago Dr. Van Allen, who is one of the most knowledgeable space scientists in the United States, said that in his opinion there is no question whatever that Canada is third in the space race, and that, after the United States and Russia, there is no other competitor than Canada. This was a little hard on Britain and France, but this was his opinion. I do not think I would agree with it, but it is nice to hear it said. At any rate, we have really done quite well in this field, but we need to have a co-ordinated program, and it has got to be directed toward a national need.

We have a need for communication satellites, for resources satellites and for weather satellites. At the very least we should be partners in these ventures. This is a good example of the sort of thing that we have already recommended.

We need to start probably several programs in the field of human environment, human ecology, and particularly something in the field of attacking our urban problems.

Transportation is one problem to which we desperately need to apply more science. We have in Canada a unique dependence upon transportation. We probably spend in total more than any other country on transportation. We have not a single good institute of transportation in a university. We are turning out very few qualified graduates in transportation. There are more in transportation economics than there are in the natural sciences related to transportation. Nobody has ever done a good systems analysis of the entire Canadian transportation system. We have a grain collection system that was designed in the horse and buggy days, and yet it is an important element in our society. So there are obvious problems in transportation just staring us in the face.

The Chairman: Do not forget that Dr. Solandt was formerly a Vice-President of C.N.R. in charge of research.

Senator Bourget: Oh, yes, I thought you had some sort of organization there for research.

Dr. Solandt: Other areas for major programs are water resources and other fields where actual action is going ahead, and in effect we are already beginning in Canada a major program in this field. Computer science and technology—using this in a very broad way to include all the applications of computers in information transfer, in supplying information to industry and educational institutions, the use of these techniques in educational technology, the automation in industry and so on—is an area in which we must identify our peculiar needs in Canada and concentrate our efforts. We are concentrating a lot, but it is too diffused.

Northern resources development is another obvious field of importance. The use of science in technology in foreign aid is one that I personally feel that Canada can do more in, although we are doing well. Then there are other fields that have been suggested such as food and materials, and so on.

The Science Council's plan is to recommend a series of probably five or six broad areas from this list. There may be others. We hope to get this recommendation out this summer. Then we would propose to set up committees, not just comprised of Science Council members but of the best people we can find in Canada, to try to narrow down the choices within these fields to sufficiently narrow areas that they can be acted on quickly and effectively, and then to advise on the broad lines of organization for implementing each of these major programs. I do not visualize that you would set up a special office for each program because some of the programs fall naturally within the responsibilities of existing departments. But others do not. They cut across departments and you might need a new agency, as we felt you did in the field of space.

Each program would be planned and guided by one agency, probably in nearly every case in the federal Government. As I say, it might be an existing or a new one. Each of the programs would involve all the parts of the scientific community, government, universities and industry, and they would each involve all the parts of the scientific mechanism, all the stages from basic research right through to production and use.

Honourable senators, just before I conclude, I would like to say that this and other recommendations by the Science Council have revealed a gap in government organization which is beginning to worry us quite a bit, and I feel that this committee might well consider it. We might take as an example the recommendation that there should be a space agency. The Science Council did not feel that it was appropriate for it to say to the Government exactly the form and the nature of this agency. This is a matter for decision within the government organization. Yet, when you look at it, when this kind of recommendation comes to the cabinet—and even if they say "It is a good idea and we ought to do it," —they have no uncommitted agency to give this to for implementation. In the case of space there are agencies that are already deeply involved, the Defence Research Board, the Department of Transport, the National Research Council and the Department of Energy, Mines and Resources.

Senator Bourget: What about HARP? What about the High Altitude Research Program of McGill?

Dr. Solandt: I was wondering how to answer that question without making a long speech. That was the reason for my hesitation. I would be happy to deal with it during the question period. You see, there is an organizational problem here and if you give the task of setting up a space agency to any one group which is already involved, they are naturally biased and they feel their particular interest is the most important one, and you will probably get recommendations that are not planned objectively to meet national needs. What is needed is some uncommitted, unbiased group who can go over the whole field and who can make recommendations as to how the organization should be set up. They might suggest that it should be given to the Department of Transport or the Department of Energy, Mines and Resources or perhaps they might recommend that there should be a new agency.

This is a very important job because the success of the Science Council recommendations depend not on the organization but on the skill with which it is carried out. But the first step on carrying out the recommendations to a particular organization on a policy for science is to recognize that there really is not any agency of government suited for doing this. In the case of space organization the cabinet set up an ad hoc group within the Privy Council Secretariat, with the Science Secretariat leading, and I think they are making good progress, but I am not convinced that an ad hoc group is the right one. I would like to see some group in the Government given a continuing responsibility for viewing specially the whole of government organizations and certainly the organization of science because science is a very complex problem within the Government. It pervades all sorts of agencies, and certainly the Science Council as it sees its likely recommendations in the future is going to be producing a series of recommendations that are going to require some adjustment of organization, and some changes in organizational pattern.

Honourable senators, just to conclude I will try to sum up. It seems to me first of all that Canada has done pretty well in the use of science in the past. We have nothing to be ashamed of, and other countries envy and admire the work we have done. We have not reached any spectacular peaks of achievement; we have had only one Nobel prize in science and that was 40 years ago, but we have maintained a very high average.

Our problem is not to completely reform science in Canada. It is to start from this good foundation that we have and adapt it continually and rapidly to the growing and changing needs of the country. As I say, we have to maintain our good base in fundamental research, and we have to expand it as the resources of our country expand, and we have to achieve our main expansion of science in Canada in its economic and social applications.

I think the priorities are pretty obvious. First of all we must support economic growth because it is the growth of the economy that pays for everything else. If our economy is not healthy and expanding, there is no use talking about even fundamental research. The second priority must be to support education, health and similar things. Without education and without good health we cannot go ahead. The third priority is to support the various projects we have discussed to improve the quality of our life and the success of our society.

Obviously we do not do these things in sequence—one, two, three. We have to do them all at once, and our real problem is to be sure we have a well balanced program because they are all interdependent. If we go overboard and put too much money into social projects, we will not be putting enough capital into the growth of our industry. Therefore we have to be sure first of all that we have a firm foundation in industry. But then if we do not put enough money into our social and research projects we are in danger of losing our best people to the United States. It is really a problem of achieving a dynamic balance between these three goals: economic growth, education and health, and improvement of our society. I am optimistic that we can do it, and I think we can do it without any revolution; we need to do it by the process of rapid evolution.

The Chairman: Thank you very much, Dr. Solandt. Some of you yesterday complained that our meeting had been too long. I wonder if you would want to adjourn for a few minutes or if you want to go on.

Senator Sullivan: It might be a medical necessity.

The Chairman: Before we do adjourn I would like to ask if Dr. Petch has something to add at this stage.

Dr. H. E. Petch, Vice-President, University of Waterloo: I think not. I did not prepare any statement. However, I would like to say that I am in substantial agreement with what Dr. Solandt has said. I think it is only natural that I should differ in emphasis and on some questions of detail, but certainly I am in very substantial agreement and would support what Dr. Solandt has said.

The Chairman: We will adjourn until 11.15.
(Adjournment)

UPON RESUMING:

The Chairman: The discussion is now open, and I will ask Senator McCutcheon to start, if he wants to.

Senator McCutcheon: Mr. Chairman, we had some discussions yesterday with the Canada Council about the possibility of obtaining an inventory of scientists and scientific expenditures in Canada, and I was interested to hear Dr. Solandt say that the Science Council, has prepared inventories in certain fields.

Dr. Solandt: Yes.

Senator McCutcheon: Is it proposed to carry that right through the whole field of the natural and social sciences?

Dr. Solandt: We plan to carry it through the natural sciences and engineering. We have not made any plan to carry it completely through the social sciences.

I may just say a word about the relationship of the Science Council to the social sciences. I personally had always felt that the Science Council ideally should cover all the sciences, but that there might be organizational reasons why it would be wise to separate the natural from the social sciences. However, even if they were separate the Science Council would have to deal with those aspects of the social sciences that were immediately adjoining the natural sciences, if you like, even if there were an overlapping in responsibility. I say that because, particularly when you look at problems like the development of our cities, you just cannot hope to tackle these separately from the point of view of the natural and the social sciences. As you see, in the Act there is nothing that either says it should cover the social sciences or it should not.

Senator McCutcheon: No, it refers to the social aspects of life in Canada.

Dr. Solandt: Yes. This was deliberately done in order to permit it to evolve whichever way seemed sensible. We have been seeking to cooperate with the social sciences as much as possible, and the only active cooperation we have is in a study of federal support of research in the universities, which is now going on under Dr. Macdonald, former President of U.B.C. Dr. Gaudry is the Chairman of the Science Council Committee that is doing it, and I would hope you might invite him to come and report on that study at some time in the future. It is getting close enough to completion, I think, that within a couple of months' time they could report. It covers the natural sciences, the social sciences and, to some extent, the humanities in the universities.

Senator McCutcheon: But only in the universities?

Dr. Solandt: Yes, only in the universities.

Senator McCutcheon: And only federal Government support?

Dr. Solandt: Well, no, it is going to look at all the sources of support for research. Curiously enough,...

Senator McCutcheon: Including, let us say, U.S. support?

Dr. Solandt: Yes, because it is quite an important element.

Senator McCutcheon: But still that will not give you the full inventory?

Dr. Solandt: No, it will not really be a complete one, but I think myself it will be quite complete enough as a guide for policy. In these fields you do not really need a 100 per cent inventory to know what is going on; 80 per cent will give you a perfectly good feel.

The Chairman: Are you making arrangements so that this study will be followed up and will be made more or less on a continuing basis after it is completed?

Dr. Solandt: No, we have not made any such arrangements, but I think they should be made.

Senator MacKenzie: Have you had any unhappiness indicated on the part of those in the humanities, due to the connotation of the Science Council and scientists being in charge of the study?

Dr. Solandt: There were indications of some unhappiness.

Senator MacKenzie: I would expect that.

Dr. Solandt: But then we arranged to have a representative group from the social sciences and the humanities put on Dr. Gaudry's committee, and in the working group under Dr. Macdonald also to have social scientists added. The reaction I have got unofficially from the universities since then is excellent. It is amazingly good. In fact, half-a-dozen universities told me that initially they were not looking forward to a visit from Dr. Macdonald and his team and that they could see all sorts of problems. However, afterwards they said, in each case, "It went off extremely well. They understand our problems". They felt they communicated well. So, I am quite optimistic about the result of the study, which did start with quite a little friction.

The Chairman: I have asked Senator McCutcheon to lead off the discussion this morning, as I will ask other members to do the same at our future meetings. So, honourable senators, if you would let Senator McCutcheon ask all his questions first, then we will try to have a fair distribution.

Senator McCutcheon: In connection with these inventories that you said would be made available to us, would it be more than simply a set of figures, or will there be included a view of the Science Council as to whether or not a particular area is being adequately covered?

Dr. Solandt: So far they have been done by consultants and have been published. Of those which have been published the major one is *Physics in Canada,* which was done by the Canadian Association of Physicists. The team was led by Dr. Rose, formerly of N.R.C., and it was published with their comments on what was right or wrong, but with no comments from the Science Council. Our idea was, and still is I think, that we would try to get a reasonably complete inventory before we tried to make comments, because it is pretty difficult to say whether there is too much or too little physics in Canada until you know how much there is of other things and what the conflicting claims on the resources are.

Senator McCutcheon: You referred to your curiosity-directed research. Obviously, that research will not necessarily be of special utility to Canada, and you referred to the importance of the applied research being directed, as far as possible, to unique Canadian objectives. At the same time, Dr. Mackenzie emphasized yesterday—and I think you touched on it—the debt that we owe in Canada to research and development which is undertaken in other countries, because scientific developments become quickly available to the whole scientific community, if they want to take advantage of them.

You may prefer not to say anything on this, but I was wondering in which category you would put the HARP project, whether we took the proper decision or whether there is not some obligation on Canada to pursue a project like that, particularly when it does receive substantial support from probably the leading nation in research and development.

The Chairman: You have the next half hour, Dr. Solandt!

Senator Bourget: Do you have a long speech to make on that?

Dr. Solandt: I should say that I am somewhat unhappy with the ultimate result in the HARP situation, although I do not think it is at all catastrophic from the point of view of the Canadian scientific effort. That is, HARP was an interesting exercise in applied science, not in fundamental science. It can be used as a research tool in various kinds of quite fundamental research, particularly in the upper atmosphere. It really has no unique use in Canada. The only reason for backing it in Canada would be that it was an idea that was exploited in Canada. I may say it was not an idea that arose in Canada, because the first firings of this kind, as far as I know—and they probably were not the first, there were probably others done in other European countries—were done in England in 1943 or 1944 when I was with the Army Operational Research Group. We were responsible for the scientific side of them. They were done at Dover using a 16-inch gun firing an 8-inch shell which got up to 100,000 feet, and which was used for upper atmosphere research. It was a very interesting problem.

When the first intelligence arrived about the V-2 rockets it was realized that no one knew enough about the upper atmosphere above 30,000 or 40,000 feet to know how far they would go, and what the trajectory would be. This was a project to get meteorological data up to 100,000 feet and it worked very well.

The whole HARP project was an integral part of a project carried on by the Canadian Armament Research and Development Establishment (CARDE), and it was based on technology evolved over several years. There was, first of all, the Sabot technique which General McNaughton had a great deal of confidence in, and which was developed by a team at CARDE. This is a technique using a disposable lining to fire a sub-calibre module from a big calibre gun. This presents all sorts of problems, such as finding the right propellant in order to achieve the velocities necessary, and then the development of all the telemetering to get the messages back from these things in space. It is quite a difficult problem to get radio transmitters that will stand being fired from a gun. That work was again done at CARDE.

What Dr. Bull did was the very original development of what was going on, so I think it is a great pity that it was not kept within the Canadian defence program and guided and developed intelligently. It got out of the defence program and got treated in a way that was out of all proportion to its relative importance. I think it was something which could have been developed quite modestly and intelligently and successfully within our program.

I hope I have conveyed that it was the right idea, that it is a good idea. It is an interesting bit of applied science, but it is not desperately important to Canada. I think it has been given prominence out of all proportion to its real importance. The team has done excellent work. They are first-class engineers and scientists. As far as support from the United States goes, it looks like big money to us but it is just the crumbs from the great man's table, so far as they are concerned.

Senator McCutcheon: I appreciate that, but it is more substantial support than we were giving.

Dr. Solandt: Yes.

Senator Bourget: Is McGill completely out of the program now?

Dr. Solandt: I think so. I could not answer that authoritatively, but I am pretty sure it is.

Senator Bourget: And from what I have learned of the project, the University of Vermont, or the United States Government, have bought, or are supporting financially, the organization now.

Dr. Solandt: Yes, and I see that they are doing firings in Barbados now, with support from the British.

Senator McCutcheon: Yes, one of the British universities has come in and is providing money.

Dr. Solandt: To my mind, this is an ideal way of using the HARP project. They are using it as a research tool. They are not paying for the development of the technique. They are just using it as a research tool.

Senator Bourget: Because they had a good young group of engineers in basic research, and I think it was a very interesting program.

Dr. Solandt: It was.

Senator Bourget: And I was wondering why our Government let it down.

Dr. Solandt: Well, I think it would be more appropriate to ask the agencies that.

Senator Bourget: I know, but I just wanted to get your reaction to it.

Dr. Solandt: Well, I would agree with you that this was a very competent group of bright young people, and my reaction to a group like that is always this: if you do not feel like supporting what they are doing then try to find something more exciting for them to do that is important. This is going to be one of our continuing problems in Canada.

Senator McCutcheon: We have lost a good group of people.

Dr. Solandt: I am not sure how many we have lost.

Senator McCutcheon: I do not know how many either. The newspapers carry various numbers.

Dr. Solandt: There have been various reports as to the number that have actually gone.

Senator McCutcheon: As I recall, from quickly reading some of your recent speeches, you have expressed some regrets about the abandonment of the Arrow program. Would you like to elaborate on that?

Dr. Solandt: Yes, I have expressed regrets on the abandonment of the Arrow program because, to my mind, it was, first of all, such a far advanced project that it attracted the interest and stimulated the imagination of all sorts of scientists and engineers in Canada. It was raising the standard of industrial capability in all sorts of industries as subcontractors. I am quite sure that the negative effect when it was cancelled was very large, and it spread throughout industry and throughout the research community.

Being wise after the event, I think the mistake that was made in this case was to try to do everything in Canada, and make everything brand new. The airframe, the engine, the radar, the fire control system, and all of the electronics—everything was new. It would have been far wiser to plan a much less ambitious program, doing possibly only the airframe or, at least, only the airframe and engine, and putting in equipment that could have been bought elsewhere. If this had been done I think it could have been carried through.

I am quite sure that if you did an economic analysis now and showed what we paid for the other aircraft that we had bought instead of the Arrow, and of the loss of production not only in the aircraft industry but in a lot of related industries, history would show that the country is worse off economically because of the cancellation of the Arrow. But this is only a hunch. I have not seen an economic analysis. No one has tried to do it. But, I do feel that we have got to avoid that kind of thing in the future. We must try to do some big and exciting things, but we have got to try to be damn sure they are within capability, and that we do carry them through to completion.

Senator McCutcheon: It is a little better in those cases to err probably on the side of over-expenditure than on the side of under-expenditure?

Dr. Solandt: I think so.

Senator McCutcheon: I notice, Dr. Solandt, that you made no reference to medical research. Was that deliberate?

Dr. Solandt: Well, I did mention...

Senator McCutcheon: You mentioned it as a second priority—education in health.

Dr. Solandt: Yes, it was one of the priorities. This was because you will be hearing from Dr. Malcolm Brown who will give you a complete outline of what is going on. Incidentally, in that field the Medical Research Council has been keeping, and it continues to keep a very good inventory of what is going on in medical research.

Senator McCutcheon: But this will be a field that you will touch on in your recommendations to the Government from time to time, at least so far as priorities are concerned?

Dr. Solandt: Yes.

The Chairman: It is included within the scope of your activities?

Dr. Solandt: Yes, we certainly visualize it as being in the scope of our activities.

Senator Thompson: But you do not include that in the list of priorities you gave us.

Dr. Solandt: No, because this list of major programs is envisaged as an addition to what we are now doing in order to stimulate growth in new directions. It is not intended to exclude a continuation of what we are doing, or even an increase of what we are doing. We did not put health services in that list because it is already going well, but it should be continued and expanded. Here I think it is important to think not just of medical research. This is another important problem, and we must think more and more of the health services as a whole.

Senator McCutcheon: Would you agree with the national goals as set out by the Economic Council of Canada, speaking broadly? You made the point that our work in this field must be directed towards national goals. That implies that the first thing which must be determined is what the national goals are. The first report of the Economic Council spent quite a bit of time on that. Would you broadly agree with those goals?

Dr. Solandt: Yes, and the Science Council's view is that we should work very closely with the Economic Council. Dr. John Deutsch was one of our members from the beginning, and Dr. Smith is also a member. We are increasingly having the staffs work together, and we would accept their economic goals as those that science should work towards. I think the economic goals are not the whole story.

The Chairman: I understand also that the Economic Council will devote its annual report this year to science and technology.

Senator McCutcheon: I see.

The Chairman: So that will complement it.

Dr. Solandt: I have already seen their working paper on it and we are having a meeting with them in two weeks.

Senator McCutcheon: Economic goals are not necessarily the only goals, but are the first priority in your assessment of priorities?

Dr. Solandt: I think so, because if we are not successful economically we cannot have the resources to do anything else we want to do. I do not rate them as being the most important in the sense that this is what our greatest aspiration should be, but I think they are the base from which everything else arises.

Senator McCutcheon: They are at the bottom of the pyramid.

The Chairman: According to your definition of mission-oriented research, it seems to me that this is where you will want to get, as a science council, the views of scientists in the life and physical sciences, but also those of economists and sociologists, in order to better define the general priorities, even in the field of the physical and life sciences?

Dr. Solandt: Yes.

The Chairman: Are you taking steps to get that kind of collaboration for your definition of priorities?

Dr. Solandt: What we hope to do, having defined these broad areas, and having formed committees which would include social scientists and economists, is to define more specifically what we want to do. It is all very well to say that you want to study and improve the modern setting, but you cannot start a program of action on a statement like that. You have to focus down to something of manageable size, and it is at that stage that I think you want all the different disciplines coming in.

Senator Grosart: Dr. Solandt, I believe you gave "national unity" as the first of your national goals and priorities. How would you relate this to scientific policy?

Dr. Solandt: I do not think that it is an area in which science has a critical contribution to make. I think it can contribute in some ways. Probably one of the most important ways is in our mechanism of communication. Because we really do have a remarkably homogenous scientific community in Canada. In any particular discipline, the French-speaking scientists and the English-speaking scientists know each other intimately and get along well. So this is a very important thing.

The Chairman: Would you not say also that this is perhaps where the social sciences and the humanities have the greatest contribution to make in this field?

Dr. Solandt: Yes, they have a very large contribution to make.

The Chairman: For instance, I remember that before the Royal Commission on Bilingualism and Biculturalism started its work, the social scientists in Canada had never worked together on such problems, and in many cases did not even know each other. And yet, some of us are surprised at the limited knowledge we have in this area.

Dr. Solandt: But I think this was not true in the physical sciences, in mathematical science, and so on.

The Chairman: No, no.

Dr. Solandt: You might like to say something, Dr. Petch?

Dr. Petch: Not on this particular point.

Senator Thompson: In one of your speeches you suggested that the scientific backgrounds of the English-speaking and French-speaking Canadians are different. It is suggested that English-speaking Canada has a prosaic and rather safe approach to science, not terribly imaginative; whereas the French-speaking Canada has more vitality and, again perhaps because of other reasons, has gone into social science; but you were expecting that it would bring the vital imaginative approach in the more true sciences at a later date, and you see it developing now that there are more French-speaking scientists coming into scientific research.

Dr. Solandt: I am sad to say that the statistics of the rapid growth of science in French Canada indicate a great preference for the social sciences rather than for the natural sciences and engineering. I do not mean by this that there are not extremely able leaders in every field of science in French Canada, but I had rather expected to see much more growth of the natural sciences and engineering, much more rapid growth than there has been.

I still support what I said before, that the French scientists, and particularly the social scientists, and the ordinary educated French Canadian, seems to me to have a more lively interest in life then the English Canadian. Probably, in the speech you referred to, I think I compared the two subways, Toronto and Montreal, as an example of the difference in culture—and I am sufficiently a Torontonian to think that the Toronto one is very good.

Senator Grosart: In regard to what you said in the historic perspective, the increase in interest in the hard sciences in Quebec has accelerated greatly in the last few years, in the long-run respect?

Dr. Solandt: There is no doubt about this, but what I said is that I am unhappy to see that the undergraduate registration in the universities does not reflect a very rapid growth. I think there is greatly increasing interest in them but students are not going there yet.

Senator Bourget: Is this the case for a polytechnic, for instance? I graduated in 1932 in polytechnic and we were only 24 who graduated. Last year there were 275 or 280. It has been growing all the time. I think it is the same case at Laval, though I am not too sure, and you can correct me if I am wrong. In the Province of Quebec in general, I think there have been more students in applied science faculty, like polytechnic, and Laval?

Dr. Solandt: There has been a good steady growth. My point was that with the tremendous increase in interest in industrialization in Quebec in the last five years, I would have expected this growth to accelerate.

The Chairman: I think this situation is explained partly by the fact that the growth in the physical and life sciences preceded the growth in the social sciences. I am sure you remember the period when social sciences were more or less identified with heresy in the Province of Quebec. I do not need to give you any dates.

Senator Bourget: Or names.

Senator Grosart: Or any specific example.

The Chairman: At that time very few students were going in for the social sciences. The situation has now become more normal, but in the process, and relatively speaking, the social sciences are recruiting more than the other sciences.

Senator Desruisseaux: If we take comparative figures of the increases in the other provinces, we find that we are not doing as well as we should?

Dr. Solandt: I think that is so.

Senator Grosart: You have rightly emphasized the importance of the political decision-making process in the selection of priorities. We seem to be doing research into other matters. We have the Economic Council, the Science Council, and so on. Are we doing enough basic or applied research into the efficiency of the political decision-making process, as it applies to scientific policy?

I am not asking you to comment on the efficiency of the process, but on the research that is being done. I have tried to raise this with most of our political scientists but I find they are almost all on the opinion level, rather than on the scientific, directed to the scientific efficiency of the system.

I asked the question yesterday and the answer was given, "Well, the alternative to our system is dictatorship." I do not believe that to be so. I believe there are other alternatives to our particular system of political decision making such as the American system. I am not advocating it, but I am asking if there is sufficient research today into our own political decision-making system.

Dr. Solandt: I am not really qualified to give you a good answer on research by political scientists. From what I know I would say that research in Canada on this kind of thing is inadequate. I do know that particularly in the United States and to a considerable extent in Britain and to a lesser extent, to my knowledge, in France, there are groups whose approach is that of the operational research worker or systems analyst, who is working at political systems, and they are looking at the political systems in the kind of quantitative terms—or trying to—that you describe. So there is research going on in these fields, but so far as I know very little is being done in Canada.

Senator Grosart: And in France, too?

Dr. Solandt: Yes. Most of the work I know about is in the United States, however.

Senator Grosart: This is just a minor question, but we have in the federal Government a standards and specifications office. I have made some inquiries as to the way it operates and it seems to me that at the moment it has a very minor status in the hierarchy of the Government. It seems to be at the moment halfway between Defence Production and the Canadian Transport Commission. Is this an efficient operation or is it important, this specifications and standards operation within the federal Government?

Dr. Solandt: Well, it certainly is important. I do not know enough to really be able to comment authoritatively on how well it is functioning. That is an area with which I have not had much personal contact.

Senator Grosart: One of the reasons I asked the question is that we often hear, as we heard yesterday, questions about automotive research, automobile safety, and so on. So far as I know we are not in Canada doing any or very much research in that line. We are relying upon the Americans.

Dr. Solandt: Yes. So far as I know that is true.

Senator Grosart: Should we not be doing more of our own research in this field?

Dr. Solandt: I think I would be willing to accept the American efforts in safety and other things of that kind. If we put effort into the automobile field or land transportation field, I would much rather see us put our effort into developing both improvements to existing vehicles and new vehicles suited to our climatic problems.

Senator Grosart: That was really my point, Dr. Solandt, because a New York State study that I saw recently is only partially applicable to conditions in Canada.

Dr. Solandt: Well, I think it is a great pity that we have not devoted a fair amount of effort to becoming the world's leaders in cold weather and over-snow transportation. We have had several goes at it at different times and we have done fairly well—mostly through private enterprise; for example, Bombardier in Quebec and Robin Nodwell in Calgary. To my mind this is a good example of the kind of specialization that I was talking about. But if we try to meet the United States automobile industry head on, there is no contest. But they have failed to specialize in things like cold weather operation and over-snow transportation, and so on. Therefore, there is room for us to do something in these fields which might be very useful.

Senator Grosart: I believe we have done some pioneering in road engineering in Canada.

Dr. Solandt: Yes, I think some.

Senator Thompson: May I follow on this question, Mr. Chairman? I noticed that one of Dr. Solandt's "hobby horses," as he referred to it, is Arctic research. I hope I am not taking this out of a confidential speech, but I understand that you have rather deplored the withdrawal from the Arctic of the defence forces, suggesting that defence research geared to indigenous industry would be far more productive and is the particular kind of industry that we should be concerned with, and that this particular kind of industrial research should be geared to our climatic conditions. Following that logic, it would seem that you would still like to see a greater emphasis placed on defence research in the

Arctic than there is at present in the Arctic. Would you like to elaborate on that?

Dr. Solandt: I think that one could use what I just said as a good example. I would have far preferred to see the Canadian Armed Forces spending their money on perfecting an over-snow vehicle than on perfecting—what was the memorable vehicle?

Senator McCutcheon: The bobcat.

Dr. Solandt: The bobcat, yes. Curiously enough, the bobcat project started out as an over-snow vehicle project over 15 years ago, but it got lost along the way.

The Chairman: In the snow.

Dr. Solandt: But my point here is that, while an over-snow vehicle is not a prime requirement for Canadian services, it is nonetheless an important one. It is a very minor requirement for, say, the Americans, but I am quite sure that if we developed the best over-snow vehicle in the world they would probably buy it from us, whereas if we developed the best ordinary battlefield carrier we would be running into direct competition with the United States because this is one of their prime requirements. Even if our end product were the best, they would not buy it because theirs would be very good as well.

Senator Lang: Dr. Solandt, I presume that Canada now has quite a large financial stake in nuclear research and in the development of certain types of nuclear reactors. I also assume from things that I have read in the press that perhaps we have encountered difficulties at Douglas Point recently in the practical application. I noticed, again recently, that we lost a contract for a nuclear reactor in Argentina and another for one in Germany as well, I believe. In the final analysis, so far as purely monetary aspects are concerned, I imagine that the success of our nuclear programs would depend on whether we take precedence in certain fields here and are able to export our technology after development of it at home. I wonder if you could give me and the committee any comments of yours on our present position in this field.

Dr. Solandt: I would be glad to give you my own views. I am sure you will get views from Lorne Gray of Atomic Energy of Canada Limited. As I see it, Canada chose to make a major effort in the field of atomic energy. It started, as you know, during the war, and we have followed it up and have been successful. We have produced some of the best experimental research reactors in the world and we have produced, in Douglas Point, what I think is a very good power reactor. The troubles at Douglas Point, as I understand it, have had nothing at all to do with the nuclear elements of either design or fabrication. They have all been failures in auxiliaries, particularly pumps. This is so often the story of nuclear reactors that the problems are with what appear to be the rather normal components of the system than with the nuclear components.

But I feel quite strongly that we now have got so heavily and successfully into nuclear power that we should reinforce our successes and make sure that we are competitive. I think our problems are more at the industrial production end of the system than they are with either the nuclear physics or the engineering design. This is where the older, more mature industrial economies such as Germany, Switzerland, France, Britain and so on have this more solid foundation for the construction of things like pumps and so on. Of course, we tend to buy a good many of them from the United States. However, to sum it up, I think we have got a good lead in this field and it is important for us to reinforce our success and to stay in the lead. The reasons why I think we should stay in it are, first of all, that we are important producers of uranium and will be probably even more important in the future. We are producing reactors that use natural uranium and so they can use uranium from Canada whereas many of the others require a mixed uranium that they have to buy from the States. In addition we will be major customers for nuclear reactors ourselves. We are going to have quite an industry just building the ones we need for our own use.

Senator Grosart: How far away are we from commercial use of nuclear development as power?

Dr. Solandt: As power? Well, Douglas Point was delivering something like 150 megawatts over the peak of Christmas this year and tided Ontario Hydro over a very difficult peak. So we are there now.

Senator Grosart: How competitive was this pricewise with hydro or coal?

Dr. Solandt: I have not seen final figures but in the United States they consider their more modern large plants are thoroughly competitive. As you probably saw, the future orders in the United States call for 50 per-cent nuclear power, and there is every reason to believe that the new big plants being built in Canada, at Pickering outside Toronto and Quebec, will be thoroughly competitive.

The Chairman: At least with thermal power—with coal.

Dr. Solandt: Yes. With coal and any hydro developments there is always a difficulty of transmission. But nuclear plants have the big advantage that you can put them near the point of use. Hamilton Falls, for example, is not in a very convenient location.

Senator Bourget: How serious is the situation regarding young engineers and scientists leaving Canada to work in the big companies in the United States in the research field, and in other countries, but particularly in the United States?

Dr. Petch: Well, it is one with which we have been concerned. I am not perhaps as concerned as others because coming from the University of Waterloo where we have a co-operative system that allows the students to become very familiar with what Canada has to offer, we find now that fewer than one per cent of our engineers take jobs outside the country. This is one of the tragedies of the cancellation of such things as the Arrow project. I have never been and I am not in a position to evaluate it as a defence weapon, but I think the country has lost very heavily by its discontinuance. I was very close to both the metallurgical industry and the electronics industry at that time and I feel we have not yet regained the impetus in those two industries that we lost on the cancellation of the Arrow project. We were gaining an experience in these industries which if the Arrow project had continued on would have meant that we would have competed very well and very favourably and I think could have built up a considerable competence in these fields. In the metallurgical field where we are basic producers—we ship the material out in ingot form—the Arrow project gave great impetus to developing secondary industry particularly in the use of such things as titanium and magnesium. If this project had continued it would have meant that we would have seen much more development in secondary industries than we have. It is the loss of exciting projects like this that cost us considerably in terms of our very best manpower because our best people tend to be excited by these projects. It is the challenge of the projects that interests them. This is where we are lacking. There is lots of what I call bread-and-butter engineering in Canada but there is not very much to interest the top 15 per cent of our graduates in applied science.

Senator Bourget: Taking into account the research field, they feel perhaps they have a better chance to learn more in this field in the United States than in Canada?

Dr. Petch: It is not that it is better research, but it is a chance to take part in a really challenging technological development that costs us our applied scientists and engineers. We have very few projects that present this sort of challenge to our young people. It is very difficult to get started even in companies now starting R. and D. laboratories. It is difficult to attract young people because they realize—perhaps they have their Ph.D.—they have a great deal left to learn and they know that if they go into a big R. and D. establishment in the United States they will be surrounded by people who have a great depth of knowledge and technique. So they realize that they will be learning for years. If they accept a position in one of our Canadian R. and D. establishments, they know they will be close to the top man and there is a possibility or a danger that they will stop learning here. This is very serious.

Senator Desruisseaux: This will affect the thinking and the stability of the young scientists?

Dr. Petch: Yes, it does.

Dr. Solandt: Apropos of your remark, I was in the manned space center in Houston, Texas, recently and they support the view that I had often heard from Hugh Dryden, who used to be second-in-command in NASA, that the United States space program received a major impetus from the cancellation of the Arrow project. Of the 200 scientists involved in their program, 40 came from Avro and most of them are still there, and at the manned space center out of the half-dozen we met, three of them were from Avro. I might say they were all Englishmen—not Canadians—who had come to Canada intending to stay.

Senator Phillips: You mentioned that one of the major programs should include research policy in transportation. Being well aware of your experience in this field, I would like to have your views as to the form this study should take. In other words, what we should be doing in the research field in Canada.

Dr. Solandt: Well, I might just say a brief word about this in a sort of systematic way. The Science Council has now an understanding, which is not more than just the results of discussions with the Economic Council, that we will try to plan a joint study on transportation, because obviously the economic aspects of transportation are very important. The object of these initial studies is to try to find out (a) what is going on in research in transportation in Canada and what do we think should go on. After finding out what is going on and planning what we think should go on, then we would make some recommendations as to organization. I have talked this over with Mr. Pickersgill and he is very willing and anxious to have this go ahead, because although the new transport commission has been given responsibility for research, they have not really formulated their plans and it could be very helpful to them in formulating plans and would probably result in some kind of decision as to how research should be divided between the various agencies concerned. But there is no question that the real problem now is to try to get going in one or more Canadian universities a good transportation research institute that will train people for work in this field. I always used to boast, and I think it is still true, that the only good transportation research institute in Canada was the R. and D. department of the C.N.R. We had a total of 300 people—perhaps only 30 professional people—but the C.N. being a big enough company to have interests to pervade the whole transportation system, we really had a good organization. Unfortunately, however, we did not have graduate students, and what we need is something like that in one or more universities.

This is a critical matter, because until we get a flow of well-trained transportation research workers coming out of the universities, we do not have the material on which to start, say, a good feasibility study in Government.

I feel that transportation economics is relatively stronger than the others. There is a fair amount of research on transportation in geography departments. What is conspicuously lacking is the systems analytical approach to transportation problems which combines the outlook of a systems engineer with good economic analysis.

As I see it, broadly, the first thing we have to do is to try to decide in a general way how should our transportation network be made up, what should the balances be between railway, highway, pipeline—solids, liquid and gas pipelines—air, water, and the others. We have to get at least a general feeling for the best balance. Then, as I mentioned, there are specific transportation problems, of which grain transportation is the outstanding one.

Senator Phillips: Do we have anyone keeping in touch with the British research in Hovercraft, where they are appearing to develop Hovercraft trains which will travel at much higher speeds than our present freight trains?

Dr. Solandt: There are several agencies, both in the Government and privately, that are keeping in close touch with what is going on. The Hovercraft particularly—not the train, but the water or cross-country vehicle—is being quite effectively investigated as to whether it is useful in Canada. The trains are still in a pretty early stage of development. In fact, I think the French development is most advanced at the moment.

Senator Bourget: Were your researches in the C.N.R. research branch limited to railways?

Dr. Solandt: No, we were concerned not only with railways but with competitive modes of transportation. We had a group that studied truck transportation. I think we had the best pipeline costing group outside the oil industry itself. We had to know what their costs were to compete with them. We worked with Air Canada a fair amount, particularly on air freight problems. So, the group had quite wide interests. This, I think, is essential for a big transportation industry. In fact, transportation in North America in general would be much more satisfactory today if about 50 years ago the railways had thought of themselves as transportation companies rather than as railway companies. Then we would have developed an integrated road-rail transportation system instead of two competitive modes of transportation.

Senator Bourget: But you did not have any labs; it was only theoretical studies?

Dr. Solandt: No, the C.N. has lab facilities with a staff of about one hundred. They are concerned primarily with materials research and are also the basis for the quality control in purchasing and inspection.

The Chairman: We might wait to discuss this further when the C.N.R. will appear before us.

Senator Bourget: Oh, I am sorry.

Dr. Solandt: But I may just say they have done some quite good original engineering research and, in fact, they are making a fair amount of money out of some of their patents, which is gratifying.

Senator Kinnear: Several years ago, probably in 1961 or 1962, I thought it would be a good idea, in view of pipelines carrying various commodities, that grain should be transported in that way. I learned that the University of Alberta had done some research in that field. Are they continuing in that line? They were going to put grain in capsules so that it would be in first-class condition when it arrived at its destination. It seems to me such a long haul from the prairies to the eastern seaboard that a great deal of research should be done on the carrying of grain.

Dr. Solandt: I think it is fair to say that the Research Council of Alberta is now the leader in the world in the field of research in solids pipelines. The idea of transporting grain by pipeline is an old one. I think the early studies were done by the N.R.C. 30 or 40 years ago. They were going to blow it through the pipeline. It has proved entirely satisfactory, but it produced a marketing problem. There was a question of how you would sell this large, coarse whole wheat flour.

Senator Kinnear: That is the point; it has to arrive in good condition.

Dr. Solandt: The University and Research Council in Alberta have now shown you can transport wheat either in pellets of some kind, or they have even tried coating the individual grains and suspending them in oil, so you get a mixture of oil and wheat. I think that so far none has looked to be economical.

One of the great difficulties of solids pipelines—and when I was with the C.N. we looked into many specific examples—is that in order to make pipeline transportation economical you have to have a major movement from one point of origin to one point of destination, and it has to be a homogeneous product.

You may have read in the press that they had recommended reducing the number of grades of grain from 300-and-something to 200-and something. This immediately almost rules out transportation by pipeline, because if you are going to have several hundred different grades, you cannot separate them. I might have said the grain transportation problem is a beautiful example of an intricate systems problem that pervades so many different disciplines. It is not just a problem of grain transportation, but you have to solve problems of grain grading, which is one of the most difficult, and many of the marketing problems are tied in. It is a marketing problem, really, with a strong technical element.

Senator Kinnear: Another thing I would like to refer to is Senator Bourget's question on engineers. I noticed in your overall statement you said you thought we have an adequate supply for the next 10 years, probably; but I noticed that in the field of research on nylon, Dupont Nylon at Kingston had to give up their research department, supposedly because of the Kennedy tariff, and that whole area is closed out. I know some of the engineers from that area, and they are finding it difficult to get placed this year. These are experienced chemical research engineers, so I think probably this seems to be a poor year, even for the graduate engineer who is now coming out of school and is looking for positions this year. What do you think of the prospects of their finding employment—either of you, or both of you?

Dr. Solandt: You probably know the answer to this one better than I do, Dr. Petch.

Dr. Petch: This question is more difficult here, I agree, because there has been some reduction, particularly in technical staff, this year. It is always more of a problem for the senior people—because of higher salaries, pensions and so on—to move.

Generally, I am not worried at all about meeting our manpower needs, except in a few areas. I think there are going to be some critical shortages, such as a shortage of computer scientists and people in transportation, but generally when I look at the students we have in the graduate schools today, and in the undergraduate schools, I am quite convinced there is not going to be an absolute manpower shortage, although there will be threats developing in certain areas, and quite severe ones.

Senator Kinnear: And over-supply in others?

Dr. Petch: There will be over-supply in other areas, yes. In metallurgy, for example, which is for some reason not attractive, it has been very difficult to obtain a sufficient number, and so far I cannot see any trend to correct this. On the other hand, electrical engineering is very attractive to young people, and I do not think there will be any problems there. I do not think there will be any shortage in the basic sciences, but when you see the things we are trying to develop in transportation at the University of Waterloo you will understand that we face a very severe problem in keeping our staff. There is a shortage of people, and they are offered such enormous salaries elsewhere because of the critical need of consulting firms in cities, that we are continually under pressure. Yet I can understand the demand for these people, and the need for them. But, if they take these jobs and leave the university then we are not going to be able to train students. So, it is very short-sighted for others to take these people away, because they are well qualified to train students, and it cuts off the supply.

Senator Grosart: I wonder if there is any other reason for this apparent lag in the development of transportation studies at universities, particularly in view of the fact of the importance of transportation in the Canadian economy. At the risk of dating myself and Senator MacKenzie, I recall that some of his colleagues at the faculty of the University of Toronto 40 years ago stressed transportation studies. Professor Harold Innes, I recall, required us to spend hours on a definitive textbook by Professor W. T. Jackman, at the University of Toronto, if my memory is correct, in addition to other onerous reading given to me by Professor MacKenzie, as he then was. Is there any reason why in these 40 years we have not developed this apparently obvious specialty study in Canadian universities?

Dr. Solandt: I would say it has been principally due to the slow development of technical competence in the transportation industry. This is an off-the-cuff view. It is not really the result of careful analysis, but if you look at the number of competent people involved in transportation studies of any kind that were employed in the Canadian transport industry ten years ago you will find you could pretty well count them on your fingers. There is not very much inducement for students to go into a technical field like transportation, or universities to become particularly interested in it, unless there is some relationship with industry. Probably a good deal of the blame goes to the railways who really were not very interested in research, or in the problems, even, of transportation as a whole, until recently.

The Chairman: I think we might come back to transportation later on.

Senator Grosart: But does not this relate to the whole field of urbanization problems. It is not just the railways, but roads and traffic.

Dr. Solandt: Yes. Well, you will find there is a fair number of universities which are giving courses in highway engineering. Some of them are giving courses in traffic engineering. We, of course, have a fairly good record of research in aeronautics in Canada which is one of the hardware sides of transportation. So, we have not been completely lacking, but it has amazed me to understand why there has been so little emphasis on transportation as a national problem from the scientific point of view. There has been lots from the political point of view. It is a case where the politicians have been way ahead of us.

Senator MacKenzie: Mr. Chairman, I have a number of topics noted here that I would like to discuss with our guest, but I think most of them can wait for another occasion. There is only one that is a matter of importance, and that is what is called urbanization. It has been stated a number of times. I agree that this will become increasingly important. I have not yet understood why, because of the distribution of authority, if you like, and responsibility of this kind, this cannot be intelligently dealt with in the present circumstances. You get a city council that perhaps does not have enough revenue to do half of the things it is supposed to do, so it says it cannot do them. Then, at the same time the city expands beyond its limits and increases the problems. Now, in a sense, it is the basic organization of the understanding of the solution of this situation that has to be tackled first, apart from the piecemeal operation.

Dr. Solandt: Yes, I would agree that this is true, and that many of the most important solutions to the problems really lie in the field of politics, or political science. How do you organize a nation, the communities within the nation, to bring our resources to bear on these problems, but even if we had the organization now we, in many areas, do not have the answer so that we can start looking.

Senator MacKenzie: Who could undertake a study of this kind? The Science Council is not a research organization.

Dr. Solandt: I think we are going to have to develop in the country some major institutes for research of this kind. This is something that the chairman probably has more definite views on than I have. It seems to me that a study of the whole social and political structure of the nation is something that would very well be done by a somewhat academic institute, maybe associated with a university, but it needs quite a large number of people.

Senator MacKenzie: I am sure of that.

Dr. Solandt: And a large number of different areas of views and interest.

Senator MacKenzie: The evidence we have seen developed in the United States, and in Montreal, Toronto and Vancouver, and the probabilities of unlimited growth in these cities, do make it, I think, one of the most urgent problems that confronts society today.

Dr. Solandt: Yes, we have seen in Canada some good minor examples of how science can help. It is only natural that I should give Toronto a boost, but those of you, for instance, who have seen the computer operated traffic lights in Toronto in operation were probably quite impressed. This was work that was done entirely by Canadian scientists in Toronto, and it has been adopted in many parts of the world.

It is also interesting to note that probably the best information on the impact of the subway on rider habits that exists in the world has come from Toronto, and it is again being used as a basis for predicting what is going to happen in all other cities that are putting in subways.

So, there are some very heartening examples of what science can do to solve the problems of urbanization, if the political organization and the resources are there to deal with it.

Senator MacKenzie: There is another subject that is related to this, Mr. Chairman, that I would like to put in the record for further study, and that is highway safety. Again, this is very important, and is increasing in importance, in the urban communities, and generally throughout the country. It is, perhaps in some ways, of greater concern to the people in the social sciences—in psychology, and in psychiatry, if you like—then it is to technicians and engineers, but they are both involved. It is something that I think deserves early and very serious consideration.

Dr. Solandt: Yes.

Senator MacKenzie: It ties in again with the topic you mentioned earlier, the safety of vehicles, which you suggested was probably, in our circumstances, the job of the United States. The other matters that I have noted, Mr. Chairman, can wait.

Senator Thompson: There is one point, sir, on which I would like some more clarification. It is in relation to the future field of responsibility for new agencies.

You raised a number of national projects. I understand they come from the Science Council, in the report presented to the cabinet for later decision. Then I did not quite follow you. You said there are some kinds of in-cabinet decisions in which the allocation of this project should go into the field structure. I want to be clear. Do you suggest that the allocation might go back to the Science Council rather than have the cabinet make it? Furthermore, I wonder if behind that there was an inference, in cabinet, because some more ambitious cabinet ministers are anxious to build up their departments and feel that some particular project should be within their department. This may not mean necessarily an orderly evolution of development. I wonder whether you viewed that as a kind of hodge-podge in speaking of a research department, and if that could be more clarified?

Dr. Solandt: No. The point I wanted to make was that, to my mind, this sort of organizational problem should not go back to the Science Council because the Science Council cannot be responsible for the organization of the Government and the exact pattern of organization depends on many factors other than science and has to be determined. This is one of the cabinet's jobs. On the other hand, you cannot expect the cabinet itself to make the detailed analysis which is needed to decide how a new function should be organized.

My point is that it would appear that there should be some group serving the Government who had no commitment to any particular department and were available to do the analysis and present to the cabinet the pros and cons, the alternatives in organizational solutions.

Senator Thompson: To be more specific, do you think of this now, for example, in the Defence Department, that in the allocation of research there is overlapping in various departments at the moment and that there should be a co-ordination of research departments?

Dr. Solandt: No. On the whole, the co-ordination of research within the Government is pretty good. It is done principally at the working level. Scientists do not particularly enjoy duplicating other people's work. Often, when they hear that somebody else is in the same field, they go and talk to them and work out joint programs so that their work will be complementary rather than competitive. I do not think the problem of duplication is a serious one.

Space is a good example. The problem here is that at present you have the Defence Research Board which is doing the satellite program. They are doing a research satellite program, the ISIS series. There is the National Research Council, operating the range at Churchill and supporting a lot of research projects relating to space in the universities.

You have the Department of Transport which is intimately connected with the problems of satellite communication and how it should be organized, regulated, and so on. You have the Department of Energy, Mines and Resources who are very concerned with the possible use of the satellites for resource exploration and are already working with the United States on it.

Each one of these has a real genuine interest in something connected with space. But if you ask any one of them to enunciate a national space program and say how it should be organized, I think each one of them would say, "That is easy, just give it to me, I will look after it." And they will look after it, but they will produce a program which is conditioned by departmental interests rather than national interests. What we need is something that will make it possible to plan and organize a structure which will evolve a program on a national basis rather than on a departmental or regional or sectional basis.

Senator Thompson: Thank you.

The Chairman: You mentioned a moment ago, Dr. Solandt, that the Science Council, in your view and according to the Act, was probably covering the whole field of science policy. I have here a quotation from a statement made by the Minister, the Honourable Mr. Drury, in the House of Commons, during the discussion of the legislation establishing the Science Council. He said:

> I think I made it quite clear at the outset of the discussion on the resolution that sciences and scientific research in the sense used in this bill in relation to the Science Council relate to the so-called natural sciences and not to social sciences.

I understand your problem, and you have certainly defined it very well this morning. As we move into mission-oriented research, it becomes less and less possible and certainly less and less desirable to separate all these different sectors. But it seems to me that you have at present a conflict of responsibility, at least a separation of responsibilité. You have to agree that the policy of the Government, perhaps not as explained in the wording used in the legislation, but according to the intention of the legislator, is that your Council should be limited to the field of the physical and life sciences.

Dr. Solandt: That was a statement he made in response to a question, and I have never tested it to see whether it is a statement of government policy or not. All I was saying was that the bill is so worded that we could encompass the social sciences, if it were thought desirable. My feeling is that the social sciences must be represented at the national policy level, and social sciences must be considered in formulating national policy, on an equal footing with natural sciences.

This can be done either by expanding the terms of reference—you do not have to expand the terms of reference but just say that the Science Council does include this—and of course by adding social science to the Council.

It would be ridiculous to have the present Council saying they are dealing in social science. Or it can be done by a companion body, but if there is a companion body, then the two should work closely together. There must not be a borderline or a fence between them, with overlapping as a result.

The Economic Council you can see is concerned with national aspects of social science, but it is now devoting quite a lot of time to studying research in natural science and engineering, because of its impact on economic growth. I think this is fine.

In the Science Council we have spent considerable time working on the economics and about the impact of industrial research, particularly on economic growth.

I am sorry that there is not more dialogue now, particularly in what you might call sociology. The term "social science" seems to me to be too all-inclusive. Economics is brought into our considerations regularly, but we do not sufficiently bring in problems of how people behave and how groups and organizations behave. This is the kind of sociology I mean.

The Chairman: It seems to me that there is probably a gap there in the government organization. As I understand it, it is not the responsibility of the Canada Council to look at this kind of problem. Various departments are doing research in the social sciences, but there is no real centre with which you could have a dialogue.

Dr. Solandt: That is right.

The Chairman: You were also mentioning the problems of organization, and this has been raised by Senator Thompson. But you felt in your main presentation that you were not perhaps in a position at this moment to give us detailed comments on the organization of science and research within the federal Government. I certainly hope that you will be able to come back before our committee after you have published your report. Do you think that that will be in August?

Dr. Solandt: I would hope that it would be approximately in August.

The Chairman: August or September. At that time, so far as we are concerned, we will have gone, at least we hope we will have gone, all through the federal agencies doing research. Therefore, we might put that question of organization on the agenda of our next meeting with you so that we might discuss not only the substance of your report on the goals of science policy but also your views on how the organization of that policy might be improved.

Dr. Solandt: Yes. I would not like to leave with you the idea that the Science Council is likely this summer to come up with any radical ideas for reorganizing.

The Chairman: Oh, no, but I am sure that you have some views yourself.

Dr. Solandt: Yes.

The Chairman: And perhaps we will have more precise views ourselves at that time.

Dr. Solandt: Yes.

The Chairman: Once we have gone through the second phase of our inquiry.

Dr. Solandt: Yes.

Senator Lang: Dr. Solandt, in a recent incident a remark was made to me that rather shocked me, simply because it runs so contrary to the general tenor of the discussion today. Recently, in a post-prandial discussion with an economist, whom I will not name for fear of misquoting the gentleman but who was at the University of Toronto as a centennial lecturer and who spent many years at the University of Chicago...

Dr. Solandt: I believe you have identified the gentleman.

Senator Lang: He made the remarks that we were far too preoccupied in Canada with developing indigenous research in all the sciences and that we are keeping far too many cows and that we could buy our milk cheaper elsewhere. I do not think this remark was made lightly, but, granted he is an economist, it was made by a man who was looking at Canada from somewhat afar now. Is this type of opinion shared to any extent by scientists in Canada or by scientists abroad?

Dr. Solandt: I do not think it is. In answer to your last question—scientists abroad—the O.E.C.D. group is just starting to investigate research in Canada. You will be meeting some of them later on in June, I think.

The Chairman: Yes, in June.

Dr. Solandt: So it will be interesting to find out what their view is. But I think the view I would take, which I believe is possibly a consensus of opinion, is that we certainly should import a lot of our milk and we are doing so. But we ought to keep quite a few cows in our own pasture. Nevertheless, we have to look a little more critically at the yield of milk that we are getting from the cows in our own pasture and make sure that we only keep cows that yield enough milk to make it cheaper to get milk from them than it would be to buy them from abroad.

In fact, we have to develop the technique of make-or-buy decisions in research and development. The only nation that I know of that has done this carefully is Japan. They have, as you know, decided in many cases to buy technology rather than to make it at home, although, curiously enough, in a recent

O.E.C.D. presentation they said that they were beginning to think that they had probably bought about as much as they should and that they were going to start making more at home because they thought it would be cheaper, owing to the fact that you get so many by-products and improvements in your society from doing the research at home.

So I think your remark just puts the finger on our real problem in this industrial research in Canada, which is to know how much we ought to do here and how much we ought to import. I think, in fact it is certain, that there should be a mixture of the two and I would like to see us, as I have said, import research and development that is done on products or processes or ideas that are of primary importance to the United States and concentrate our own work on the things that are of primary importance to Canada.

Again, one of the good examples of the applications of this idea—and I do not think it was done consciously—has been the success of the De Havilland series of aircraft. You see, these were aircraft that were developed specifically for unique Canadian conditions. But these are the conditions of an undeveloped country, and you find that there are lots of other undeveloped countries in the world that have exactly the same or at least similar conditions. The African countries bought nearly all De Havilland aircraft because they have poorly developed roads, poorly developed airfields and they need an aeroplane that can take off and land almost anywhere. Had we in Canada decided to try to develop a large commercial aircraft in direct competition with the big nations we would not have succeeded at all.

So that many of our objectives in research and development will inevitably appear to be of secondary importance to other countries, but they will be of great importance to us. Of course, this raises, very importantly, the point that Dr. Petch made to the effect that if we are to keep good people in the country we have got to have some things that appear to be spectacular and important and interesting. To my mind it is one of the biggest reasons for supporting the intense neutron generator project, ING. At present, unfortunately, we are lacking projects of a calibre to fire the imagination of young people. We have got to have some. We must try to find some that are within our means and that are really important to Canada. I think ING is.

Senator Grosart: Dr. Solandt, the obverse of your statement about the Japanese position is rather interesting. A remark by a Japanese businessman reported the other day was to the effect that one of their serious problems is cheap American imitations.

The Chairman: Are there any more questions? I am sure we would all have many other questions to ask you, Dr. Solandt, but, unfortunately for us at least, this meeting has to come to an end. I am sure I speak on behalf of all present when I thank you very much for your most interesting presentation. We hope to see you again next fall.

Dr. Solandt: Thank you very much.

The committee adjourned.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Wednesday, March 13, 1968.

The Special Committee on Science Policy met this day at 3 p.m.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: Honourable senators, on your behalf I have pleasure in welcoming Professor V. W. Bladen, who has just told me that he has given up all his administrative responsibilities at the University of Toronto so as to be able to devote his life from now on to teaching. He has become again a simple professor although he was previously, as you all know, Dean of the Faculty of Arts and Sciences at the University of Toronto.

Dean Bladen has always been interested in the field of the social sciences and has followed the trends in research in this field throughout his long academic career.

We are very grateful to you, sir, for having accepted our invitation in spite of your numerous activities.

Professor Bladen tells me he was giving a lecture this morning at 10 o'clock in the University of Toronto; he is now with us and he has to go back at 5.30 this afternoon. In the meantime on behalf of all members of the committee I wish you welcome. I understand you have a short opening statement to make.

Professor V. W. Bladen, University of Toronto: Thank you very much, Mr. Chairman. I am not quite sure that I am going to do what you want, but—

Senator McCutcheon: All we want is to write a report.

Professor Bladen: But I have drafted a short statement and perhaps this will open the possibility for—the modern word is —dialogue.

I suppose it is as Chairman of the Commission on the Financing of Higher Education in Canada, and by virtue of the report of that commission being commonly known as the Bladen Report, that I have been invited to talk with you. In a sense it would have been better for another member of the commission to have done this for me, but I suppose as a member of this committee he felt it was better to bring me in.

In that report, in chapter V which was devoted to the economics of the problem, we cited the Gordon Report on Canada's Economic Prospects, the Robbins Report on Higher Education in Britain, and the first report of the Economic Council of Canada in support of the proposition that the growth in our gross national product is, in part, dependent on the level of investment in higher education. Much of what we said in support of this position is relevant to your problem of the role of scientific research and the appropriate means of financing it.

May I quote from the Report, at page 56:

> Economists who were preoccupied for several decades with problems of resource allocation and equilibrium, and then for a decade with problems of employment, have, since World War II, devoted more and more of their attention to the problems of growth. Two elements in this newly developing economics of growth are of particular significance to us. First, in earlier studies the development of technology and the consequent increase in productivity was treated as accidental: more recently there has developed a recognition that "technology" is produced at a cost by investment in "research and development". The universities, by virtue of their research activity are among the "producers" of technological change: a substantial part of their cost may be considered to be investment in the production of such change.

We went on in the report to deal with the second element, "improvement in the quality of the labour force through investment in education"—but this is not your cup of tea today.

Later in this chapter we argued that the return on the social investment in higher education was high. But we added:

> A part of the expenditure is on research or "intellectual creation". The return on this part does not accrue to individuals: it is even harder to assess than the return on higher education; but it is almost certainly high and probably becoming higher in the new conditions of technology.

Before I leave the Report, let me refer to its recommendations so far as they relate to research:

> That the federal responsibility for financing research be recognized by a great increase in the grants for research to the universities, to their staff members and to their research students, specifically:
>
> That the amounts available from the National Research Council for the support of research in universities... be increased to $40 million for the year 1966-67 and be escalated by 20 per cent each year thereafter.
>
> That the amounts available from the Medical Research Council for support of research in the universities... be increased to 20 million for the year 1966-67 and be escalated by 20 per cent each year thereafter.
>
> That the amounts available for research in the social sciences and humanities... be increased to $15 million for the year 1966-67 and be escalated by 20 per cent each year thereafter.

We made further recommendations about payment of "overhead", and of a general sustaining grant for research to be paid to universities equal to 10 per cent of the aggregate salaries of the full time academic staff. But such details are relatively unimportant compared with the argument for an increase in the funds available. There is an explanation of these more detailed recommendations at pages 75-76.

Now I do not have the figures to show me how research support has in fact increased. The National Research Council figure for 1965-66 was $21.6 million—if our recommendation had been accepted this would have been $40 million in 1966-67, $48 million in 1967-68, $57.6 million in 1968-69. I know that the amount has increased, but I do not know whether it has reached that level.

In any case I have no hesitation in saying that we underestimated the research needs of the universities: I explain this mainly by a complete failure to recognize the rapidity in the development of the role of the computer in science, including social science. On this count alone we may well have been too low by some 20 per cent. We failed, though perhaps not as badly, to estimate adequately the general rate of increase in the degree of sophistication in the equipment and therefore in the rate of increase in the cost per investigator. I think we knew we were being conservative but we thought we would be more certain to get action if we were fairly conservative. I now think we were much too conservative.

The Medical Research Council grants in 1965-66 were of the order of $7 million. If our recommendations had been accepted they would now be 28.4 in 1968-69. Again I do not know how they have increased, and in any case the block grants from the Health Resources Fund have been added. This other source of funds for research space and equipment was foreseen by our commission when we recommended that the proposals of the Hall Commission on education in the health field be implemented. I am confident therefore that this generous fund does not make our estimates of the support necessary from M.R.C. any less an underestimate than was our estimate for N.R.C.

There is one other recommendation that is relevant, and is suggested by my reference to the health fund. We recommended a Capital Grants Fund into which each year be paid $5.00 per capita of the Canadian population. While provision was made in the shifting of responsibility and funds to the provincial government for operating grants on something like the scale we recommended, no provision was made either to implement this proposal for capital grants or to make such arrangements with the provinces as would look after the need for capital grants on the scale envisaged. Absence of provision for such capital grants explains, largely, the feeling of the provinces and their universities, that the federal Government had not made a really satisfactory arrangement. The relevance of all this to "science policy" may seem remote, but it is not. Research needs space. In the University of Toronto, for example, the development of much important research activity is inhibited by lack of space. A new science building that I, as Dean, was fighting for four years ago appears now to be shelved for a decade—on financial grounds. The research component of such a building would be at least 50 per cent. The federal Government has clear constitutional authority in the sphere of research and the use of our proposed Capital Grants Fund to assist in the building and equipping of new science buildings, to the extent of the "research" component in them would give the natural sciences the sort of support that the Health Sciences are receiving from the Health Resources Fund.

Incidentally, reading the excellent report in the *Globe and Mail* on your proceedings yesterday, I noticed Mr. Boucher's plea for libraries. If this Capital Grants Fund had been in fact instituted, the problem of libraries, so far as the building part is concerned, would have been cared for in this way; and the fact we only recommended that something like $1 million or $2 million a year be spent on libraries out of the Social Sciences Research Fund was related to the belief that out of the Capital Grants Fund there would be money for the building.

Alternatively to the establishment of a special Capital Grants Fund, there might be a further increase in the level of operating grants from N.R.C. so as to cover the rent of research space—not by using up some of an inadequate grant to pay for space, but by increasing the grants and the funds from which such grants are made to cover this item. If the rent were assured the financing of building would be easy.

Now may I make some comments on these propositions and recommendations of the commission.

1. The reports of the Economic Council of Canada still seem to illustrate the continuing obsession with the problems of allocation and employment; there is a developing concern shown for education and training as a means to improve the quality of the labour force, but there are very brief references to the increase in productivity through research and development. A sentence here and there shows that the importance of research and development is recognized; but incredibly little attention is paid to the really difficult problems of promoting such activity. Yet this slow growth in productivity per man hour is made abundantly clear.

2. In our report we were concerned with "pure research" in universities. You in this committee must be concerned also with applied research and development, and indeed with innovation in industry.

Now may I say first that, while I believe that we must spend heavily on applied research, we are not spending enough yet on pure research. It must be recognized that:

Firstly, pure research at the frontiers of knowledge, though the application may be unforeseen, is essential to the development of applied research. It provides the raw material for such research and creates the atmosphere for imaginative work in the applied field. We must not let up in our search for new fundamental knowledge. We must add a new effort to find applications of that new knowledge.

Secondly, pure research in the universities has a by-product namely the production of research personnel for pure and applied research.

Thirdly, pure research in the universities has a further by-product in the education of people who though they will not be engaged in research are likely to be more effective in all kinds of productive activity because they have been educated in an atmosphere of developing knowledge rather than taught what is known by those content with what they now know.

I am quite sure that the universities are still, if not starved, undernourished. I know whereof I speak so far as the University of Toronto is concerned and I suppose this is a "have" university in a "have" province. I suspect that there may be starvation in some universities and in some regions. I am assured by Dr. John Hamilton that what I have said about the other sciences is very true today of the medical, or health, sciences. Toronto and McGill medical schools and teaching hospitals are not starving; but there are centres that are. They too must be nourished.

In the argument so far there has been a nationalistic bias, and a materialistic bias, as I have based the plea for research funds on the effect of such expenditure on our Gross National Product, thus emphasizing the "investment" aspect of such expenditure, and the "national" return. Let me qualify first the nationalistic bias.

Science is international. Nationalism in science is likely to inhibit development. But, I am not so concerned to argue the unfavourable atmosphere as to preach an international obligation. We, as one of the "have" nations, have a moral responsibility to pull our weight in the development of new knowledge. Our contribution to the pool of international science may well be more important in the long run than our present contributions in material aid to the underdeveloped world.

Having in mind this internationalism, and having in mind the disadvantages of Canada in size and location, I draw your attention to two ventures in which I think we should participate. Perhaps I am going a little too far, as an economist, in saying that we should participate in these two science ventures, but we should seriously consider them. The best Canadian location for a telescope is so far inferior to the location selected by Cal Tech in Chile that we should jump at the opportunity offered to us of going halves with that American institution. For some $5 million we could have a half share in the best telescope in the world, in a location that is nearly perfect. We are not moving fast enough to take advantage of this offer.

Senator McCutcheon: We are going to have another telescope.

Professor Bladen: We may have a much more expensive one, in a much less advantageous location, with less satisfactory arrangements for the use of it by scientists than by government.

Senator MacKenzie: You are talking from the viewpoint of the University of Toronto.

Professor Bladen: No, I am not. I am talking about science and not about the University of Toronto. The University of British Columbia is closer to Chile than a lot of our other people are.

Senator MacKenzie: I have heard this argument before.

Professor Bladen: I am not absolutely convinced by the scientists, but I have listened to them, and this to me makes sense. We are apparently committed, instead, to this—I will not say second rate, but less desirable—

Senator MacKenzie: Like your science building, it has been suspended.

Professor Bladen: Let us get the $5 million and let us go to Chile.

Similarly there are possibilities of co-operating with an American institution in high energy physics. We have not the personnel for a venture on our own, and the investment would be very large. But, we have made some use of an American installation, the Argonne laboratory, for our own research groups, and we have an opportunity to become a partner in a new venture at Weston. Again, this is something we should very seriously consider, although to the nationalist it will seem odd to increase our dependence upon the United States by entering into a partnership in a joint research activity.

May I next say something about the "materialistic" bias. Here there are two points to be made. First, having in mind the favourable effects on productivity of developing knowledge, let us be as concerned with the possibility of improving the quality of life as we are with increasing the quantity of material goods, and let us be particularly concerned to understand and control the unfavourable effects that accompany many increases in productivity.

In particular, I direct attention to the research programs necessary with reference to pollution and urban blight. I will go further and argue for research, as we argued in the Bladen Report for higher education, that an affluent civilized community should spend to develop the talents of its individual citizens. "In the long run," we added by way of reconciling our idealist and materialist biases, "we may achieve even greater wealth by this greater concern for the individual: We will surely come nearer to achieving the 'good life'."

While recognizing the idealist position with reference to education and research, I equally recognize that the scale of expenditure I am talking about in a society where there remain many things of high priority undone, because we cannot face the expense, can only be justified if there is a very good chance of a high return on the investment, or, at any rate, on that part of the expenditure that is beyond what we might accept on "idealistic" grounds.

Now I must turn from policy with reference to pure research and say something about applied research, the development of new processes, new materials, new products. And let me say immediately that attention must be directed not only at "research and development", but at "innovation", the entrepreneurial process by which new knowledge is put to work in industry. I shall also want to say something not only about the process by which new knowledge leads to new products on the market, but about how old knowledge remains unutilized (or under utilized) as actual practice falls below "best available practice".

The Department of Industry has been, and continues to be, concerned to encourage applied research in industry. Its programs will no doubt be explained to you by its officers, and their results assessed. I am sure that Mr. Reisman would agree with me that there is an enormous amount yet to be done, and that not only are greater funds necessary, but perhaps even more important is new ideas on how to promote technological advance. I cannot be very helpful in this area but perhaps I can raise some questions and stimulate some new thinking.

It seems to me that the revolution in technology of the last quarter of a century is very directly related to war and defence. In the United States the expenditure on research and development in the areas even slightly related to defence has been enormous. But the United States government not only promotes the research, and contracts with private industry to have specific research undertaken, it then provides a market for the newly developed products, so that innovation, enterprise, completes the process.

Now I think we have to try to devise a peaceful alternative to war as a source of technological advance. Perhaps we have to select some forms of peaceful products that we would like to develop. We should perhaps encourage the development of industrial laboratories, not just by tax write-off and grants in aid of their capital cost, but by contracting for the performance of research and development activity in relation to specific products. Where successful development is achieved perhaps we should then promote innovation by providing a first market for those products.

A study of the policy of the Ministry of Technology in the United Kingdom might be valuable. I believe that there has been government support for example, in the development of numerical control machines followed by government support to those industries that adopted the newly developed machines. I shall not pretend that I could select the industries in Canada that should be selected for such treatment, but I do suggest that the market in research establishments for sophisticated equipment is one of the peaceful alternatives.

Specifically the development of science in Canada requires an enormous increase in the supply of computers, and, in particular, of specialized computers. Should we not direct large funds not just to the provision of computers, but also to computer technology? Should we not contract with universities and industrial laboratories for the performance of applied research in this field, and should we not provide a good initial market for the products of innovators in this computer industry by enabling universities to buy the equipment they so badly need, and by encouraging in some way the more rapid spread of computer use in industry? Might we not in the process be developing an export industry where comparative advantage is with the scientifically advanced nations? Dr. Arthur Porter who is I believe to meet you next week tells me that attention should be directed not only to the hardware but to the software in the computer industry, not only to assure full use of the hardware, but because an export market in software is highly possible. I might add that I believe the Ministry of Technology has helped to sell numerical control machines in export markets as well as helping to develop the domestic market.

Research, as a peaceful alternative to war, may well be relevant to the highly controversial ING project. Apart from any direct product of ING by way of isotopes, or any indirect product by way of the development of material science, I believe that the development of sophisticated equipment for the construction of ING might provide some of that incentive to innovate in industry that seems to me so important. Perhaps no one has ever really considered what the Arrow did to develop skills in Canadian industry. In my view, the investment may well have paid off.

I recognize that I am raising a difficult question, and giving little help in answering it, but perhaps I should say that the proposal for contract research followed by purchase of the new product is most easily applicable for experimental purposes to those industries where governments at some level are big buyers. I think particularly of housing and transportation.

May I throw out the suggestion that more experiments like Habitat are necessary: experiments in new design, new material, and new productive processes. If we could design high-rise buildings appropriate to family living, if we could reduce the cost of such buildings by lower cost materials and construction, we would make enormous strides towards a high quality of living. And in the process by providing for research, development and innovation we might be developing new industries not only to supply our needs but to supply new export markets.

As I said earlier the Department of Industry has the major responsibility for developing and implementing programs of this sort. Perhaps they need an advisory scientific committee to help in identifying the areas where support should be concentrated, and a somewhat different advisory committee to help choose the most effective means of support. I have two comments on the existing policies, based on inadequate study of their programs and representing a desire to promote thinking and questioning rather than a settled judgment. I am worried by some of the, possibly undue, concern to recover from industry the government investment in Research and Development. I am afraid that the terms of tax relief, and cost sharing (subject to repayment) are not attractive enough. The contract to do a job for a price may be a more effective way of promoting the development of industrial research laboratories. The insistence in so many cases that funds be repaid might be rethought in the light of the high rate of taxes on profits. If Research and Development pays off for the entrepreneur, the government gets its share through the corporation tax, the public gets its share through the provision of more and/or better and/or cheaper goods. Too much concern to recover the investment in Research and Development through repayment may deprive the government and the public of the benefit which might have flowed from the inhibited Research and Development.

I am also worried by the "nationalist" character of the agreements into which the firm must enter if accepting help under most of the Department of Industry programs. We benefit so largely from foreign technology that we should hesitate to put nationalist restrictions on our own development. But further we may be ignoring the effect of our general research and development activity and of the educational effect of such activity on industry. We may gain in the process of developing a product even if we lose it to another country. If we are too careful to keep our Research and Development activity restricted to that which leads to Canadian industrial use, we may indeed restrict our Research and Development activity to our own loss.

There is one further paragraph which I meant to write and did not, so perhaps I can speak freely about it. I referred to it earlier, when I said that an enormous increase in productivity would be possible if we could bring average efficiency up to the level of the best available practice.

Senator Grosart will probably remember that when I lectured on the subject of industry and trade in the 1920s I used to refer to the Committee on Waste, the Committee of the Federated Society of Engineers of America, promoted by Mr. Herbert Hoover, which was exactly that—a study of a number of industries to show the difference between, if not the best available, the best existing in industry, and the average practice of those industries.

I have been led to think about this again when, as chairman of the Adjustment Assistance Board dealing with the automotive manufacturers, I found that on some occasions at any rate the provision of management advice has been almost as important as the provision of the capital which we had to lend.

I am interested in the fact that in the new adjustment legislation or regulations which are being developed in relation to the Kennedy Round, there is provision not only for assistance in financing but assistance in securing that kind of management and engineering advice which may be necessary to enable the firms, having got capital, to become viable enterprises, profitable enterprises.

It is a little hard to bring under the heading of "research" this rather mundane investigation of the ordinary management consultant, of the engineer concerned with assessing the effectiveness of current managerial practice or engineering practice. Yet it is the same thing, fundamentally: it is looking at what is happening, with an inquiring mind, and asking if things can be done differently.

I have this one last comment. The more we are able to promote applied research, industrial research, as we more normally think of it, in industrial enterprises, the more operating management comes into daily contact with the members of their research laboratories, the more likely management is to develop that research attitude towards its current practice.

As I say, it is not easy to see either how this fits into your terms of reference, it is even harder to see by what means you can appropriately operate to improve the efficiency of private enterprise while leaving it private, as I would want to do.

Mr. Chairman, I am afraid this is a somewhat academic address, at times impassioned when dealing with the needs of universities—not forgetting the University of British Columbia.

The Chairman: Thank you very much, Professor Bladen. You have not really changed very much over the years. You have always been deeply convinced of your own views and straightforward in expressing them.

To open the discussion, I would ask Senator Grosart—who is a former student of Professor Bladen—to lead off. This will probably be the first occasion in his life that Senator Grosart has to ask questions of a former professor.

Senator Grosart: Thank you, Mr. Chairman. That is not quite true, because I have had an opportunity to ask questions of one former professor of mine, who is here, Senator MacKenzie. He occasionally disagrees with me, but I tell him, "Well, this is what you taught me for years".

The same might be said of another colleague of Professor Bladen and Senator MacKenzie, who taught me at the same time, and may suggest that I was not a very good student—I refer to my lecturer in constitutional history and politics, then assistant professor Lester B. Pearson.

If I may digress for a moment, I well remember listening to Professor Bladen, as one of his students, and we had some difficulty in following him as he delivered his lectures at a very rapid pace, as you will have noted. We got together a little rebel committee and appointed one fearless individual to see Professor Bladen and ask him if he could not possibly slow up. The answer came back that if we could not keep up to him we should not be there.

Professor Bladen: That is a myth.

Senator Grosart: Perhaps this applies to the committee today. I must admit I had some difficulty in keeping up with Professor Bladen. So, after forty years, things have not changed very much.

The first question I would suggest that Professor Bladen might enlighten us on is the magnitude of this short fall in the federal Government contribution to the universities. Some of the figures he has given us would indicate that it is of a rather alarming magnitude. He has made it clear that he is not aware of the exact figures, but one that stands out, for example, is that in 1966-67 the national research grant would have been $40 million if the recommendation of the report had been carried out. It was $21.6 million. And it would have been $57.6 million this year, if the escalation clause had been carried through, and so on, through the other suggestions. Without necessarily going on figures, Professor Bladen, how serious is this short fall in relation to scientific research and technological research and development?

Professor Bladen: Well, Senator Grosart, I am about two years out of this. At the time the report was written we knew pretty well what was happening in general, and I knew very well what was happening with regard to my own department in the university. I am now completely out of the administration of the university, and I really mean that. I keep right out of it. I have not followed the extent to which our proposals were implemented. On the other hand I can say something that looks rather better. I am told that at the moment the proposal is to escalate the N.R.C. grants by 30 per cent a year, but I am not sure from what figure or whether they are up to what we proposed. And even if they are, whether this is enough is another problem.

I do know that the number of scientists has increased so rapidly that the amount available distributed amongst them means that a great many people are getting much less than is necessary for effective action, and at the same time that the number of scientists is increasing the sophistication of the equipment they need is increasing.

In order that I should not be completely off, I must say that I did talk with Professor Harry Weld of Physics, Professor Don LeRoy of Chemistry, Dr. John Ham of Health Science and Dr. Arthur Porter, of Industrial Engineering, who is particularly concerned with computers, and I have no hesitation in saying that there is still a very considerable deficiency. But I suspect that we do rather well. What is happening to other universities which are less well established is a rather more frightening prospect. You cannot afford to concentrate science in two or three places. I do not mean that you should cut back in Toronto and in McGill and in British Columbia, but you cannot be happy so long as they thrive while Dalhousie and the University of Saskatchewan are starving.

So far as Toronto is concerned, there is a further problem, one which I am sure applies to other universities, and that is the problem of space. N.R.C. does provide grants for operating, and to some extent for equipment, but the operating grants are not adequate and the equipment grants, I suspect, are even less adequate. At the moment, however, any real advance in science is inhibited to a considerable extent in Toronto by the fact that we need more laboratory space. And this is research space. But there is no federal provision for research space and there is as yet no federal acceptance of the responsibility for university space at all. Nor was there any provision, so far as I know, to the provinces of funds to look after even that degree of capital expenditure that we estimated in the report and which, again, was probably conservative.

Senator McCutcheon: Outside the health funds.

Professor Bladen: Outside the health grants. Even there—and here I am dealing with a detail that illustrates some of the problems of bureaucracy—the health grants lead to a rather curious relationship between M.R.C. and the health fund. The M.R.C. will not make any grants until 18 months after the building is up and equipped, but you have to get your staff together before that.

The Chairman: I am told, just as a matter of information, that the budget for N.R.C. grants in aid for the fiscal year 1968-69 will be $60 million. I do not know if this covers only grants to universities. It may cover a wider area. It might include also grants to industry, but this is surely a very big increase.

Professor Bladen: I knew there had been a big increase. I was not sure whether it had yet caught up. But, as I say, I think it is 20 per cent short anyway.

Senator MacKenzie: May I interject a question Senator Grosart raised as to the priorities in respect of tax moneys in various areas. I have some concern with the financing of the universities and colleges in Nova Scotia, which is one of the areas that you have properly described as being "starved". They have limited tax revenues. What is your estimate of the priorities? This applies all across the country, of course, which is the only reason I raise the question.

Professor Bladen: Do you mean the limited provincial tax revenues?

Senator MacKenzie: Yes.

Professor Bladen: In my view, research is a federal responsibility and the financing of research in universities is a federal responsibility.

Senator MacKenzie: But even the federal Government has not got unlimited tax revenues.

Professor Bladen: No, of course it has not.

Senator MacKenzie: I am asking you, then, whether there are priorities.

Professor Bladen: Of course there are priorities, but the argument that I make, and that our commission made, is that there is an investment aspect, and, if you are using tax funds to increase not merely the tax base but the standard of living of the next decade, this has very high priority.

The Chairman: Would you say, for instance, that the lack of a capital grant program is an important gap?

Professor Bladen: This I think is a very big gap and I would be very much happier to see it made good by the establishment of either a capital grant fund or an agreement about grants in support of research from the federal Government than by transferring the additional funds to the provinces. I think there is a really important problem of making sure that this goes into research. This is the way it will pay off.

Senator MacKenzie: I wish someone would do a memorandum on this issue of the amounts, the share of the total income of a country, that could go to various general heads.

Professor Bladen: Well, at any rate, we know that the share in the country where growth has been most rapid has been about 3 per cent, which is some three times that of ours.

The Chairman: I am sorry, Senator Grosart. I want to come back to you, but just to follow up this question, if you allow me, would you know anybody, Professor Bladen, who has worked for your committee and who could do that kind of work rather quickly?

Professor Bladen: A good deal of it is available in the records of the O.E.C.D., I think.

Senator MacKenzie: You see, as a practical illustration, the revenues of the Province of Nova Scotia are divided as follows: about 30 per cent for education; 30 per cent for social services; 30 per cent for highways; with 10 per cent left to run the province. I suspect this is relatively true across the country. Now, it may be that education should go up to 40 or 50 per cent. That is what I am getting at. And in the federal area, research might go up very substantially, but you must either raise more money, or you must redistribute the money, and it would be very useful to a lot of people, if we could have a serious memorandum on this particular issue.

Now, I am done, sir. I apologize to Senator Grosart.

Senator Grosart: Not at all.

Senator MacKenzie: He raised the point in the first place.

Senator Grosart: I was going to raise a corollary question arising out of a remark of Dr. Solandt this morning when he said, as I understood it, that it was not really a question of setting a percentage of the gross national product as the amount required to solve this problem, but that we should look at specific problems and total them up and then we might find ourselves having to spend something like 4 per cent or 5 or 6 per cent of the gross national product. The question I was going to ask you was comparatively of current expenditures and in spite of that qualification, where does Canada stand? I know there are O.E.C.D. figures available but I do not have unqualified faith in them having had a look at them in relation to external aid where they are not reliable at all as they affect Canada. Where does Canada stand at the moment among leading industrial nations in relation to the percentages of expenditure of G.N.P. in scientific and technological research and development?

Professor Bladen: I am not an expert in this field. I haven't done original research in it, but so far as such information as is available to me is concerned, it suggests we are rather way down the list and possibly that we are spending in proportion to our national income about one-third of the amount the Americans are spending although some estimates make it one-fifth. I think we are deficient at the level of pure science and we are grossly deficient at the level of applied science. I think we probably are incredibly slow at the point of innovation. Although I think we can do ourselves great long-run damage by switching funds from pure research, yet I think an increase in the applied field would produce relatively quick returns, and the amount extra for pure research would not make very much difference to the percentage of the gross national product. If you add an almost equal amount to applied research, then you are really beginning to do things.

Senator Grosart: Senator McCutcheon has called my attention to a chart in the First Annual Report of the Science Council of Canada which for the record is perhaps worth just summarizing. This is a summary of eight countries and it shows the United States of America as making gross expenditures on research and development at slightly over 3 per cent, the United Kingdom at slightly over 2 per cent, the Netherlands about 1.8 per cent, France about 1.5 per cent, Japan about 1.5 per cent, Germany about 1.3 per cent, Canada just over one per cent and Belgium about .8 per cent. Now could I ask you if, in your opinion, Professor Bladen, Canada moved up to 2 per cent, would this have a significant effect on the question which the economic Council is calling our attention to so much in these days, the per capita productivity in Canada?

Professor Bladen: This is to some extent a matter of faith; it is impossible to prove it would, but all the evidence and all the analyses suggest that it would.

There is perhaps another point that I should make. I think I noticed in somebody's statement a suggestion that we could not move up that much because the scarcity is not of money but of men.

Senator McCutcheon: I think that is the point that Dr. Mackenzie made.

Professor Bladen: There is some point to this, but don't take it too seriously. At the moment the shortage is of equipment for the men and space for the men, and a very considerable increase in expenditures is required to make full use of the men we have. It is true that if you grow very fast you begin to need more bodies, and these are slow to develop, but a considerable advance is possible with the bodies we have and given that considerable improvement in the conditions for those bodies, the increased supply of bodies—I have been reading in the "New Man" recently, you know, the director of the laboratory wants more "bods"—the production of scientists depends on this flow of research funds as well as does the production of new knowledge. So that I do not think that any increased expenditure that is possible, having in view the financial problems of the Government, is likely to be on such a scale that it would become impossible to spend it effectively.

Senator Grosart: I am going to ask one more question. I know there are many questions that could be asked arising out of your very interesting presentation and I know there are others who have questions to ask, but I would like to ask just one more. As chairman of the Automotive Adjustments Assistance Board, would you care to comment on the reports we have had recently that some of the companies owe the federal Government a great deal of money under that agreement? What happened? If this is so, what went wrong?

Professor Bladen: I am not sure it is true. I think there are two companies where we may be facing bankruptcy. One of them we knew was a considerable gamble but we thought it was worth taking. I don't know yet what the situation is because this will be reported to us at the next meeting of the board, but I have been talking to the secretary. I suspect we have been well protected by security; the trouble is we have not done what we wanted for employment and productivity in the economy, but I am not sure we have lost any Government money. In fact my worry there is always the same; I am not sure we are not a little too tough in our banking attitude. We are not quite as tough as the Industrial Development Bank, but in my view the objective is to try to get industry developing and employment increasing, and if you are too careful you may save the Government some tax money indirectly and lose the gross national product which is the ultimate source of its revenue.

Senator Grosart: But don't these amounts mentioned merely represent a shortfall in productivity in Canada, and that was anticipated—in fact it was the essential aspect of the agreement.

Professor Bladen: I am not sure that I understand what you mean by that, but I would simply say that we are in that part of our program trying to make available financing for industrial development which appears after very careful engineering and examination to be viable but for which the ordinary capital market cannot make provision.

In general, any loan company, even Roy-Nat, I have no doubt, has its failures. You cannot lend for development and always be right, but I feel pretty confident that the net result will be that we have recovered most of the money we have lent and that we will have increased productivity.

Now, we believe it is important to maintain anonomity because, to some extent, if you go for help to the Board, which will only help you if you cannot borrow anywhere else, it is in a sense, advertising something about your credit.

However, I have been excited by one venture where we have been able to promote the development of what I think is a really important technological advance. I suspect that if I talk about it everyone will begin to know what it is, but here is a case of a firm which has developed a pilot plant. This is applied research through development to the point of being ready for industrial use. If it were not for the agreement, and if it were not for our ability to finance as a result of the agreement, this would be a development in the United States.

I sounded very international in some of the things I said, but, nevertheless, where I can see a Canadian development developing in Canada, I prefer it. This, again, is one of the cases where I have been happy to see us able to promote innovation. This is the most difficult thing of all, to get the thing to the final stage.

Senator Grosart: I will pass on, if I may, Mr. Chairman.

Senator Thompson: I would like to raise one small issue, this Canadian innovation in moving through to the development. I was suspicious you were referring to some Crown corporation which would develop and produce for Canada. You talk about putting all this effort into research and development in the direction we have in time of war, and if we could do the same thing in peacetime. I realize you were sitting with Senator McCutcheon on one of these committees! This is the kind of thing you are suggesting, that we move into production from the establishment of Government support all the way through.

Senator McCutcheon: Professor Bladen is a better Tory than I am!

Professor Bladen: I think I can show you precisely how different what I am proposing is by analogy with the war experience. The United States government is not organizing the production of its own missiles and its own airplanes and its own this and its own that. It is contracting with private industry, and this is what I am talking about, but it is contracting with private industry partly to have research done. This research it wants done it does not have done in its own laboratories. It invites industry to do the research, to develop a product to perform a particular task, and it pays for this. And if industrial firms were able to be selling a product, research, as well as selling a product, the gadget, then part of the pay-off of the research organization would be the revenue from the sale of research, and this would make it more possible for them to have a research unit which was paying off also in terms of increasing their own activity. Once having developed the new gadget, and the Government has paid for it by contract, then the problem is: Is it going to be made? But, again, instead of having to wonder whether you can sell it, you have a made market there; the Pentagon is wanting to buy a million units of it.

In the course of thinking and talking with people about my appearance here I got some documents from Mr. Orr, the Industrial Research Advisor in the Department of Industry—and I hope that he will be amongst those you will hear very early on. I was rather interested. I had not talked to him about this peacetime alternative, but I find him there discussing, amongst other things, the fact that the Government is the biggest buyer in so many items that it could specify and ask for the development of some new and better gadget, and pay for the research and then buy it. But, says Mr. Orr, the trouble is that it is only the Department of National Defence that can afford to do this. All the rest are operating on such tight budgets that their procurement officers cannot venture their funds hoping to get a better mousetrap. It makes me wonder whether this does not mean that there should be some development fund to which any Government department buying mousetraps or paper clips, or whatever it may be, may appeal and say, "We think that it would be worth spending some money on trying to get a better product. Can we have from this Development fund a grant for that purpose? Then it does not mean they have to have fewer paper clips if they want better ones, but if they get better ones the whole of Canada is going to get better ones too. As I put it at the moment, I am afraid it is a very impractical sort of proposal and yet perhaps I may quote what Mr. Orr said:

> Collectively, governments represent the largest single concentration of buying power in most countries. Therefore it is suggested that when government is a major customer it is in a position to establish requirements or specifications for the product it buys which will encourage advancement over the current state of the art. The cost of the research and development effort involved in meeting these advanced requirements is included in the selling price and in effect is underwritten by the user agency. Unfortunately, where budget limitations prevail there is a strong reluctance on the part of the purchasing agency to pay the premium for technical progress. Therefore this practice is really only applicable in the fields of defence.

Well, I was encouraged when I found that he, who really has experience of the problem of promoting industrial research, seemed to be moving towards, at least as one of the methods, this use of Government buying or big buying; and it seems to me—it is really not so much buying mousetraps—it is buying the sophisticated equipment that is required for the modern technology of research. In the old days research fed technology; now, technology makes possible research that was impossible before. It is along the line of my suggestion about Arrow, which may be again a little imaginative, but when I was studying the automotive industry I was in touch with a number of firms where high-precision engineering is important. Massey-Ferguson, for instance, told me that they had learned, and had been able, to develop methods of precision engineering by acquiring the technique, the machines, and the skilled men by providing bits and pieces for the Arrow, that were paying off in the agricultural implement industry.

So, even though we lost the Arrow and a large part of the engineering staff who were making it, I suspect that it did pay—it may not have paid the full return that Senator McCutcheon would want from his industrial enterprises, but it probably paid fairly substantially.

Senator Grosart: Mr. Chairman, Professor Bladen, in raising this whole question, has referred to the Ministry of Technology of the United Kingdom. From some reading I have done it seems to me that they have developed a very clear scientific policy along the lines Professor Bladen has suggested. I wonder if I might suggest to you that we get some information on that.

The Chairman: Well, Professor Blackett, the Scientific Adviser to the Ministry of Technology, is on our schedule of meetings for Wednesday next. He cannot be here next Wednesday, but he can be here next Tuesday. This is something we will have to discuss, but we definitely have him on our priority list.

Senator Grosart: Then there is the other kind of policy in this field which is generally called the French policy, that of relating industrial goals to Government rewards of various kinds for reaching those goals. As one aspect of the field of scientific policy I suggest that perhaps we might investigate that.

The Chairman: Before we move on to another subject, would you care to comment on this question: As far as research in the private sector in concerned, especially in Canada, since we have relatively few big corporations, what do you think of co-operative research? Instead of assisting research in an individual firm, what about trying to encourage the organization of research on an industry basis, such as we have done in the pulp and paper industry?

Professor Bladen: This seems to me to make very good sense indeed. It is only the very big firms that can afford the very well equipped and staffed laboratories that are required by modern science. There is the possibility of a co-operative laboratory, but, again, I think that a co-operative laboratory should not be working merely on the problems set by its member firms, but should become the manufacturer of research by entering into contracts with government with reference to the products.

The Chairman: Oh, yes.

Professor Bladen: I have no doubt that this is true, but you want to make sure that you do not let the combines people get in the way of it.

The Chairman: Well, we have been pretty successful in the sector of the pulp and paper industry.

Professor Bladen: Yes, but then it is one thing to combine to sell to the Americans but it is another thing to combine in dealing with a domestic product.

This may seem awfully far afield, but I have been very much concerned with this aspect of developing technology, and in any event with reference to the combines legislation there is a very great danger in competition, in that it may inhibit innovation. In the perfectly competitive economy no research would be done by individual firms, and no innovation would be undertaken. In agriculture you do it all for them because it is a competitive industry.

I notice signs of the re-emergence of an interest in trust-busting. I do not love monopolists, but I am terribly worried about the fanatical anti-trusters when I am thinking about the development of technology. I know that that is far afield, but...

The Chairman: Oh, no. As you know, the Economic Council is conducting a special study on this particular issue, but they are not yet ready to report.

Senator McCutcheon: We have a new minister and a new enthusiasm.

Professor Bladen: That is the trouble.

Senator McCutcheon: That is right.

The Chairman: It was one of my fields of interest too for some time, and I still keep an interest in it.

Senator Bourget: Professor Bladen, you have said very little has been done, and very little money has been spent, on pure research. I do understand, like many others, that there again it is a question of money, but even today do you think we would have the qualified personnel to take charge of the field of pure research?

Professor Bladen: I think you misunderstood me a little.

Senator Bourget: Maybe I did.

Professor Bladen: We have done a great deal in pure research. We are doing a great deal in pure research. We are just not doing enough. I do not think we have to be in any way apologetic about the quality of our scientific personnel. Indeed, some of them have been able to receive, when there has not been enough Canadian support, a lot of support from the United States. I think that we have the people. We are not supporting them enough, and we have not enough people in the long run. We have got to be producing more, but we have made a good start, and we have some pretty high standards in pure research.

Senator Bourget: And if we want some more can they be qualified here, or would they have to go outside?

Professor Bladen: Preferably they would be qualified here, but again this depends upon there being adequate support for research activity in the universities.

Senator Bourget: Thank you very much.

Professor Bladen: Could I pay this tribute to the N.R.C., and to some extent it raises the problem of the social sciences. The National Research Council, from its very early beginnings, used its funds to finance Canadian students at Canadian universities. Its fellowships in Canadian universities helped to build up the graduate schools, as well as the research activities of the Canadian universities in the natural sciences. We in the social sciences were a little too modest, I think, and felt that we had to send our best students away. The result has been that we got a lot of very good ones back, but we had not built up as quickly and as effectively as we should the boys at home. We are doing this now.

Senator McCutcheon: We heard yesterday that you get about 80 per cent of them back.

Professor Bladen: Yes, but this is not altogether the story. The story is also what happens to those who were not able to go out. There is a possibility now for many more of them to be developed in Canada, and this number would have been probably more, and the quality would have been better, had we been a little less ready to think that England did a better job than we did.

On the whole, I think the social sciences and the humanities should begin to make more and more of their fellowships tenable only in Canada. When we come down to details like this we see that there is another feature, and that is the extent to which post-doctoral fellowships should be made available. They are to some extent in the sciences. We probably need more there, but they do not exist in the social sciences.

Not only is it good for the development of the fellow, but it is enormously valuable in developing the atmosphere of research in the universities. More post-doctoral fellowships and more, shall I say, purchase of time from teaching are required. There are many American fellowships which will pay half the salary of a professor as long as his teaching load is reduced by a lot more than so many hours. If there were—what is the phrase?

Senator Grosart: Sabbatical leave?

Professor Bladen: Not sabbatical leave—in that case the man leaves. If there were an opportunity to buy time, if a man is appointed to a fellowship which supplements his teaching income and he is relieved and goes on part teaching salary. The Ford Foundation does this a good deal in the social sciences and I think it is a very useful practice.

Senator McCutcheon: Speaking of most doctoral work in the social sciences we heard quite a bit of criticism yesterday morning of this fetish, that in the social sciences you needed a Ph.D. and had to spend several more years to get it than you had in the natural sciences. Alex Corry—

Professor Bladen: Alex Corry, like V. W. Bladen, has no Ph.D. I used the phrase "post-doctoral" because of its analogy with the physical sciences. I do not mind whether a student takes a Ph.D. or not; if he does, I would do everything I could to try to make the behaviour a little more like that of the scientist. In other words, I would make it something more like a routine degree which a man gets at age 24, rather than like Aitchison who at about age 40 wrote a lifework as a thesis. I am not so much thinking of post-doctoral in that sense, as support for a man to have a year for full-time research in the university itself, not to send him to London for post-graduate research but to have this sort of man in the University of Toronto, or British Columbia or wherever it might be, working for a year; a sort of student who, if he has not got his Ph.D., at any rate he is beyond the point where he is working under direction, to the point where he is working independently but is not yet the mature scholar. I am not thinking of providing for retired professors, I am thinking of a young man age 27 to 30. This is a period when he is generally being overworked as a teacher. Not only would we get good research done then, but we would get him better oriented to the research and there would be more research product over the years.

Senator Grosart: A sort of scientific resident poet?

Senator MacKenzie: I like what Professor Bladen has said about fellowships and scholarships. I would like to ask him whether there is not some difference, however, in respect of those in the humanities in particular and possibly in some of the social sciences, in the valuable experience in another environment, in British Columbia, Toronto or Nova Scotia. Is there not more than the technical development of a person's education, in urging that some of them, having spent four or five years or so in Toronto or Vancouver, had better go somewhere else, if they are going to the humanities.

The Chairman: And come to Montreal.

Senator MacKenzie: Yes, it is a different environment.

Senator Grosart: Or Ottawa U.

Professor Bladen: Obviously, there is a great deal in what you say, particularly if they are going to be students of English literature, Italian literature, French or German literature; they go to the milieu of the countries they are dealing with. But this is done in addition to the requirement that, instead of learning the techniques in London they learn them just as well, if not better, in Canadian universities.

Senator MacKenzie: I agree.

Professor Bladen: Also, they do the write-up work on what they are doing in a Canadian environment, so that other people are getting the advantage. When there is a Canadian scholar, writing on a French poet, you do not want him only to be fertilizing the Paris academics: has got to be there part-time, but you want him to be working on this in your own bailiwick, too.

Senator Grosart: Is not the Canada Council moving in this direction?

Professor Bladen: It probably is, but I am now more out of touch with that than I was when I was talking about it two or three years ago.

Could I make one other statement, and again here I am raising issues that I think worth your talking with others about, rather than things I know about. I talked about university research, applied research in industry. I have not said anything about in-house research in government. But one of the problems I see is one of the development of communications between them. You know, Mr. Chairman, how serious is the gap between the professional economists of the civil service and the economists of the university. The gap in the science field is probably not so great, and yet I feel that it ought to be more possible—it is beginning to happen—for an N.R.C. scientist to be directing on behalf of the University of Toronto some of the experimental work of its graduate students.

I believe that it should theoretically be possible for a scientist in the Bell Telephone Company laboratories to direct research on behalf of the University of Toronto in a laboratory that, for certain purposes, is better equipped than any university can have.

The difficulty about all this is that at present there are so few industrial laboratories that are anywhere near the level of competence which makes it easy to break through the partly real and partly snobbish resistance of the universities.

To promote communication might perhaps promote movement; there could be more professors on leave to the N.R.C., more N.R.C. visiting professors to the universities. There could be more professors on leave in industrial establishments and more industrial scientists visiting professors in universities. I think it is at least worth your asking some of your witnesses from the United States about this, where I think there is much more movement than there is here; and asking those from the United Kingdom, whether there are not things which could be done to promote that kind of interchange in communication. Sometimes it may be that in applied research there turns up a problem that is really exciting for the purist but unless they are communicating, it may not get into the program of the pure research people. Sometimes an idea in pure research may have a pay-off for anyone in pure research, but unless there is adequate communication the possibility is lost.

The Chairman: You have spoken of the great usefulness of the N.R.C. in the physical sciences, both in terms of its contribution to assistance to universities and also through its own inner research activities. Do you not think that there is a possible gap in the field of the social sciences where we could have some kind of parallel institution which would add another alternative to the choices you were describing a moment ago? We could then buy time in universities or send our researchers to England or France, as we do now, but with that addition we might enable some of them to come to Ottawa.

Senator McCutcheon: You could make them executive assistants.

Professor Bladen: That is all right, but I think I saw in the press reports some reference to a possible social science foundation which would be a sort of an in-house N.R.C. organization. To this I react violently and negatively.

The Chairman: I knew that.

Professor Bladen: I am sure that, even if it had merits in any other sense, we have not the personnel to staff another institution in Ottawa without injuring the research in universities where the most important work must be done. So that whether some day such an institution might be a good thing, I am not prepared to say. I am skeptical. But that anything like that should be done soon I would consider to be disastrous. In the social sciences, the weakness of the universities is still so great that you must be careful not to drain anything from them.

Senator Thompson: But could they stimulate and co-ordinate the social science efforts in universities?

Professor Bladen: I do not think so. At any rate, the development of various kinds of committees of sciences in the various universities is fine, but I take it that the proposal was something like at N.R.C. where you would have a core of people doing research on their own in their own institution; and the development of a research institute of any sort unconnected with the universities appears to me at the moment to be a very dangerous form of development.

The Chairman: Would you consider that the establishment of the Economic Council of Canada, for instance, has greatly weakened the universities?

Professor Bladen: No. But they have, of course, to a considerable extent been using the university people. I am not opposing the use of university personnel in relation to particular research projects. The use of the work party, or the task force, or the research group of a royal commission, or the research group of a Senate committee—these things are fine.

The Chairman: And yet the Economic Council has about 50 qualified economists.

Professor Bladen: You know, the press is here and I cannot really say what I think.

The Chairman: Oh!

Professor Bladen: Will you guarantee no quotation when I say that so far as I know we have not been deprived of a significant number of recruits or that recruiting at universities has not been made significantly more difficult?

The Chairman: Is the press ready to agree not to quote Professor Bladen? No? It will have to be reported.

Professor Bladen: Well, I have said that. I have not got a list of the staff to peruse in order to see which of them I would like to recruit for a particular university, but I do not think that has been the problem in any event. But again this is not really quite what I mean by a research institute.

The Chairman: It is pretty close to it.

Professor Bladen: No. It is involved in day to day or year to year advice to government. It is applied research. It is not the N.R.C. type of research and I take it you were talking about an N.R.C. or a pure research institute.

The Chairman: No, no.

Professor Bladen: Well, so far as the other things are concerned, then, I am inclined to believe that more useful work would be done by more interchange between universities and the research staffs of the departments of the Government. The real useful work at that level I think can be done better at the point where it is very closely related to policy, and I would like to see a great deal more movement and much more communication between the universities and the research people of the Departments of Labour, Industry and Finance and so on. This would fertilize the universities and it would fertilize the Government. In fact, this is what takes place on a very great scale in the United States, much to the advantage of both its government and its universities.

The Chairman: But the kind of research which is done or which should normally be done by departments is much more related to what we call development work, development research, which just precedes policy decisions or policy formulation. I do not accept this as being applied research in the accepted sense of that expression.

Professor Bladen: Well, in my view this is the place where there is a possibility of attracting pure research people into areas that seem a little more likely to pay off. You know, I do not want too many of these pure research people to get involved so that they are doing nothing but day-to-day research for Government departments, but I am in favour of their having more contact with the Government departments. That would, I think, affect both areas of research and quality of research.

Again, you know, I get naughty, but I am a profound believer in the work of my econometric friends but I am also terribly worried unless my econometric friends should not discover what human people are like, and, above all, what the sort of people who administer policy are like.

Senator Grosart: Professor Bladen, I was going to ask you a question in that area. I have been trying to find somebody brave enough to tell us whether the political decision making process in this area might be improved, that is, vis-à-vis the Cabinet and Treasury Board departments of Parliament, and, if so, in what respects. How do you get across to the Cabinet the recommendations of a commission such as yours, the views that you have expressed? How do you get these translated into political action? Can you do it under the present political procedures?

Professor Bladen: That is an admirable subject for research.

The Chairman: The Glassco Commission is a very good example of that. They organized their own lobby within the Government.

Professor Bladen: There is something I would like to mention because it keeps turning up. On the one hand Mr. Martin congratulates me on the adoption of my plan for the automotive industry; but, of course, it is not my plan! This, however, illustrates the kind of thing one must expect. I do not think that any group of people, any royal commission or any committee, can expect to have its findings implemented. In the University of Toronto we recently appointed a committee of professors under Professor MacPherson to examine teaching in the faculty of arts and sciences. They brought out an extraordinary report. People are asking, "Why isn't it implemented?" In the first place nobody could implement it. Nobody has got the authority. But in any case all any such report can be expected to do is to change the way of thinking of people. I think it can be considered to have been useful and effective if it has had some favourable effect on the direction of action, and that it should not really expect that its findings would be implemented.

Mr. Carter, for instance, I do not think should consider the success or failure of his venture to depend on whether his report is implemented. I am prepared to say with complete confidence, however, that the taxation system of Canada will be different 10 years hence from what it would have been if that report and that investigation had not been made.

Senator MacKenzie: Coming back to the question of universities for a moment, is there value in a measure of centralization and division of labour in respect of areas of study in matters of this kind? Say we have 50, 60 or 100 institutes of higher learning in Canada and they all cannot do what Toronto is doing but most of them would like to do it—is there some value in an agreement, if it could be reached, about leaving to those equipped the major responsibility in the two levels of higher education?

Professor Bladen: Within limits, yes. I am one of those who think that there would be a lot to be said for creating a University of Ontario which would have its campuses in

Toronto, Hamilton and Kingston. I wonder too whether McGill should not be made part of a University of Ontario.

Senator Grosart: And the University of Montreal?

Professor Bladen: If there is to be a certain amount of co-ordination, it probably should be done regionally rather than nationally. I would think the Maritimes, Quebec, Ontario, the west and British Columbia are the regions in which such co-ordination should take place. There are some facilities that are so expensive it would be nonsense to duplicate them. Also there is such easy air transportation, it is perfectly possible to use the facilities of a central organization as long as those who are going to use it are given serious responsibility in respect to its government. Again to go back to the telescope, it has not been properly worked out as yet what the relationship of university to government should be. Similarly with ING I don't think there is enough care. They talk about the possibility of the university scientists playing some part in there, but you cannot come in just as a visitor. There has to be some responsibility involved.

Yesterday the problem of libraries was raised. Now, you cannot have a magnificent research library in every university; you've got to have either a lot of mediocre libraries or you can have two or three really good ones. Again it does not matter because of the speed with which you can get from the central library either the actual book or a teletype of the parts of the book you want. The technology is changing to a point where it is possible to centralize without the loss that appeared to be inevitable in the olden days. Of course, we have got to centralize and we have got to co-operate but if you carry it too far you will break down the universal character of the university which has to cover enough knowledge in the areas of the certain disciplines it deals with. The real problem is in education.

Senator MacKenzie: Surely the real problem is in what we call graduate studies.

Professor Bladen: Here again I think the small colleges and universities are making a mistake in believing that they can only do a good job if they have graduate students.

Senator MacKenzie: I agree.

Professor Bladen: The important thing in the school's character is that the staff of the undergraduate colleges is adequate and has adequate support for their research so that you can put post-doctorate fellows in them. The assumption that somehow graduate students make scholars work in the natural sciences in one way, and the humanities and social sciences in an other way. Professor MacPherson, to whom I referred earlier, has an international reputation and I am not sure it is not because he had no graduate students. I think it comes about as a result of the terrific drive on the part of the professor. It is not the only way of undertaking and developing research as a scholar. In that regard I think Professor MacPherson is a very good example. Do you not agree?

Senator MacKenzie: Yes, I agree.

Senator Thompson: You talk of federal grants in research and a federal responsibility for research, and I am thinking again in the area of undergraduate and post-graduate research. Do you see a federal department on that basis?

Professor Bladen: Not in education. You are immediately in trouble if you suggest that. When Senator McCutcheon and I were considering and worrying over this financial report, we thought of all sorts of possibilities. We thought it would be possible to eliminate entirely additional grants and do the whole thing by a sufficiently generous interpretation of "research" and by the use of income tax. In this way you could have eliminated the per capita grants and there would have been no complaints concerning the infringing of provincial rights in education. Now the question of the income tax might be a little more arguable, but certainly in so far as research is concerned—well, there are lawyers here and they may have certain views on that. But surely there can be no doubt that the federal Government has a right to support research in any institution it chooses. If you then recognize the real cost of research, and perhaps this is relevant to some of your statistical inquiries, when we started making up the material on the finances of education, we found that the usual way was to present the research grants as though this was the expenditure of the university on research. We insisted on putting it in as simply part of the revenue along with the fees. We then asked what is the research component of the costs. As a matter of fact nobody knew. At that stage the University of Toronto was, I think, the first to cost its graduate program its undergraduate program separately. But the costing of its research separate from its educational program had not been attempted. I think the University of Toronto and possibly other universities, particularly in Ontario—and I do not know about any others—have been making estimates of the proportion of their cost which is in fact research cost. I am not sure what it is, but I would guess it is about one-third. If you then look at the capital cost, and I believe I have said this already, the research component of the science building such as the physics building, the biology and sociology buildings, the chemistry building and the new building we need for geology, botany and so on in research—the research component of these will be something like 50 per cent. If you therefore took into account the real costs of research in a university, you would increase the apparent percentages of the national income going into research. I think that for comparative purposes this would not be important because I suspect that this is similarly ignored in other countries. But from the federal point of view this is important. I think you could support the activities of, at any rate, the big universities to almost the extent of one-third without beginning to invade the educational territory.

The Chairman: I have just one final question, Professor Bladen. If my recollection is correct, in your committee's report you suggested that a research centre on the life sciences should be established in Ottawa to take over and extend the activities of the Medical Research Council. However, in so far as I can recall, you did not give too much explanation of that proposal. What precisely did you have in mind?

Professor Bladen: No, I do not think we made such a proposal.

Senator McCutcheon: I cannot recall it.

Professor Bladen: As far as medical research was concerned...

Senator MacKenzie: Robie Kidd made that proposal.

Professor Bladen: ...we followed so soon after the Hall Commission that we simply endorsed the recommendations of the Hall Commission with reference to research and teaching. We did not endorse the Hall report.

Senator McCutcheon: No, we did not do that.

Professor Bladen: But we endorsed its recommendations with regard to research and teaching hospitals for the development of personnel on which later health services could be developed. We did not go into any detail about the amounts involved, but we had in mind the sort of money that ultimately came in that Health Resources Fund.

The Chairman: I was definitely under that impression. I will check back. Senator Thompson?

Senator Thompson: This is really on the other area of health resources, and we will hear from another group on this, I believe.

The Chairman: Thank you very much, Professor Bladen.

Professor Bladen: And I am not in contempt?

The Chairman: No, you are not in contempt.

The committee adjourned.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Tuesday, March 19, 1968.

The Special Committee on Science Policy met this day at 10 a.m.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: I would like first, Professor Blackett, to welcome you in Ottawa on behalf of the members of the committee and to thank you most sincerely for making this special trip from London to appear before us. I do not intend to recall now all the phases of Professor Blackett's career, because most of you already know what he has done for science in his country and throughout the world. I want only to say that he has devoted most of his life, until recently, to research and teaching. In 1948 he was awarded the Nobel Prize for Physics. He received the American Medal for Merit in 1946. And I must hasten to add that he is also a member of the Soviet Academy of Sciences. Professor Blackett has been the President of the Royal Society since 1965. At present he is on leave from the Imperial College of Science and Technology. In 1964 he became Scientific Adviser to the Minister of Technology.

As recently as last week Professor Blackett was giving evidence before the Select Committee on Science and Technology in the House of Commons in Great Britain. At present that Committee is carrying out an inquiry into the defence research and development of the United Kingdom.

I have said enough, I am sure, to show that Professor Blackett is eminently qualified to assist our committee and to give us more particularly an outline of the objectives, the general content and also the structural or administrative organization of science policy in the United Kingdom. Professor Blackett.

Professor Patrick Maynard Stuart Blackett: Mr. Chairman, Senators, I am deeply honoured to have been invited to come to Canada to appear before this special committee of the Senate and give evidence on all these matters of research and development which are playing such a very big role in the thinking and actions of the modern nations. I have heard and read something of your problems—I have been here before—and I realize that, although there are many differences between our countries, there are very many similarities in the problems that beset us over this question of the role of science and technology.

I met with your Chairman before the meeting, and he agreed to my suggestion that it would probably be best if I tried to outline some of the problems, tasks and actions that are of current consequence in my country, and some of the thoughts behind what we are trying to do, leaving it to you to apply them if they fit any of the situations in your own country.

In the last five or even ten years an increasing turmoil of thought has grown up around the role of science. On the one hand, of course, science to many people is a kind of mystic or magic wand which you wave over a country to make it rich. That is not true, but people do talk of science in that way. You have to get a much more realistic view of what science is, however, of how it should be organized and what it can achieve. And during the recent period not only in Britain but here and in Europe as a whole, and in America, intense questioning has been going on on these points. But the answers are not all that easy to find.

First I just want to make some remarks about the differences between our two countries, in the sense that our problems are rather more urgent than yours because of our extreme vulnerability due to our adverse balance of payments situation. We have almost no raw materials, except coal and now gas, in our country. Since we have to import nearly all our food, we have to export a large fraction of our manufactured goods. We are therefore intensely conscious of the extreme need for efficiency in our manufacturing industries. Now, I realize that you also have that problem, but there is the added fact that you have a great supply of raw materials which we do not have. We also traditionally have been spending more on defence also a fair amount on foreign aid. Putting all those factors together, you will see that our problems are slightly greater than yours.

Now I want to say a word about pure basic science which is of extraordinary importance for all modern developed countries. But it is not possible to qualify its achievements. The Americans, I think, have coined the phrase "curiosity-directed research" and that expresses or is indicative of the atmosphere in which most pure scientific research is carried out. So far as I know one cannot say in apportioning a budget for pure science that it should be X per cent or Y per cent of the G.N.P. This is a matter for consideration and mutual emulation. Your country is rich and you can spend more on it if you want to, but there is no royal road to a decision as to how much should be spent on pure science. In Britain today about 0.3 per cent of the G.N.P. is spent on basic curiosity directed research. This amounts to rather more than £100 million a year.

In Britain it is widely held that pure scientific research should be done wherever possible in conjunction with teaching in the universities. Only when circumstances make it necessary should it be divorced from teaching. I look upon pure science as being extremely important to an advanced nation. Within the budget which a nation provides for basic science, the scientists collectively should manage their own affairs.

I do not think that anybody will disagree about the importance of pure science, or with the fact that a material return cannot be calculated. I doubt if there are enough good people available in most countries to justify spending much more, say, 0.5 per cent of the G.N.P. on pure curiosity directed science. Pure scientific research done by people who are not very good will itself be not very worthwhile.

When one comes to consider the industrial situation, the situation is utterly different. In the first instance, the money involved is very much higher. Britain as a nation spends nearly £1,000 million a year on research and development that is about 3 per cent of the gross

national product. Once you are dealing in science of this magnitude you have to think extremely carefully: particularly when there are many other claimants to the national resources. For instance, 3 per cent of the G.N.P. could be vitally important for the housing budget, or for the education budget etc. Moreover, 3 per cent, if it could be turned into exports, could make an enormous difference to our balance of payments.

Before World War II the United States used to spend about one-half of one per cent of her G.N.P. in this field and now it is well over 3 per cent. It is this spectacular rise which has made R. and D. a big spender. As you know, in England we are going through a period of financial difficulty and Government expenditures of all sorts are being looked at very critically, including our national expenditure on R. and D. We want to be sure the nation is getting the best return on the big investment of nearly £1,000 million a year.

All science is essentially the same; there is no great difference between a scientist doing a pure job and an applied job, but the atmosphere in each sector is necessarily different. As a result of this difference, we have in Britain regarded our scientific organization in a way that some people find rather difficult to understand. We have separated Government administration of pure science from the administration of applied science and industrial development. The reason for that is that one man cannot do everything. In the field of pure science one has to be in very close touch with the universities. In the field of applied science and industrial development one has to be in close touch with industry. It is difficult to combine the two. For this reason the Ministries in England have been separated; we no longer have one Ministry to do both jobs. Pure science costing some £120 million a year comes under the Department of Education and Science. There is also a Council for Scientific Policy under Sir Harrie Massey, who advises the Secretary of State for Education and Science on all matters pertaining to science. This system works well.

The Ministry of Technology, which was started in 1964, has now absorbed the old Ministry of Aviation (MoA), and is now one of the biggest employers of qualified scientists and engineers (Q.S.E.s) of any organization in Europe. There are now 40,000 employees, including 9,000 Q.S.E.s, operating under the control of the Ministry of Technology. The Ministry has the job of running the old MoA, Defence Establishments, as well as the former Department of Scientific and Industrial Research (D.S.I.R.) Stations, and the Research Associations.

A major part of the Ministry of Technology's activities relate to the building up of a close relationship, almost a symbiotic relationship, with manufacturing industries. Though in Britain the Government spend a lot of money on research and development in its Stations, they do not manufacture—except very rarely, as at Amersham which make and sell radio-active chemical. Thus almost all manufactured goods are made by private firms. So we have to face the problem of seeing that the R. and D. effort in the Stations is linked with manufacturing firms. This is the well known transfer problem.

The ultimate test of our success will be seen in an improvement of our balance of payments position, due to bigger exports by firms. Therefore it is clear that a large part of the Government expenditure on R. and D. must be directed toward strengthening the exporting firms, making them more competitive and helping them to export more. Therefore our R. and D. expenditure must be increasingly directed towards helping industry so as to get as high a productivity as possible. Actually Britain is not doing very well on productivity; and big national efforts are being made to improve the situation. I want to emphasize again that the Ministry of Technology is essentially a Ministry of Industry. In this regard I am interested in the fact that a few years ago Canada created a Ministry of Industry, which has some common features with the Britain Ministry of Technology.

I now want to mention one or two points about what we are achieving in the Ministry of Technology and what is being discussed for the future. How does a Government, with money at its disposal, best help private firms to be efficient, to have a high innovation rate, to be up-to-date, to have good management, high productivity and high exports, within the free enterprise system? This is really the problem. There are a number of ways in which help can be given, but the one which I want to emphasize is investment in selected firms for specific projects. In Britain it was quite often the tradition in the past to give subsidies to industries in trouble, such as textiles, shipbuilding, aircraft—the latter continuously, of course! At various intervals they get into trouble and the Government pays money to bail them out. This can go too far, and we are apt to throw good money after bad. So the intervention of Government money in civilian industry is not new. It has been going on for a long time, and a step forward was taken 20 years ago when the National Research Development Corporation was founded, in Sir Stafford Cripps' day, to help inventors through the difficult stages from the initial idea to production and sales. The N.R.D.C. started slowly, but has now become quite a major part of the Government machinery for selective intervention in helping private industry. It has a fine staff, mixed technologists and industrialists, patent experts, etc. The N.R.D.C. is supporting very many projects of an inventive character in industry. Examples have been computers, hovercraft and some important drugs.

Then the Ministry of Technology has a strong Industrial Section, presided over by a Controller of Industrial Technology, who is a distinguished applied scientist, now a civil servant and a Fellow of the Royal Society. The Section has the job of being in very close touch with industry, to know what they are doing and to be prepared to help them in any way possible. The Controller has 10 divisions under him concerned with different parts of industry, and with industrial economics and statistics. Among the particular industries of special concern, of course, are science-based, rapidly moving sectors—electronics, computers, telecommunications, and so on. All these depend on high-class technology and are moving ahead very fast, so that unless they move quickly they cannot stay in the field at all. These industries are also highly competitive, meeting very strong, particularly American, competition.

The Ministry itself does give grants to selected firms, rather like your industry grants to certain projects, such as an improved machine tool system, from pre-production, to get them through the last stages of development, and so on.

Various ways have been worked out of helping industrial firms. Two years ago the Government founded the Industrial Reorganization Corporation, which is working very closely with the Ministry of Technology, though it is nominally responsible to the Department of Economic Affairs; it functions rather like a Government-sponsored, Government-financed, highly technological merchant banker. In fact, the managing director is a merchant banker; the chairman is Sir Frank Kearton, F.R.S., Chairman of Courtaulds, and it was founded to bring about changes in the structure of British industry by suitable rationalization and mergers where required. One of the troubles about much of British industry is the great fragmentation in sub-viable firms, and I.R.C. has already met with some success in improving matters. It was behind the great merger of Leyland with British Motor Corporation, to form one major British motor company. The merger between G.E.C. and A.E.A. was also sponsored and supported by I.R.C.: so was the take-over by English Electric of Elliot Automation. The I.R.C. does not have a large technical staff, but uses consultants from the N.R.D.C., the Ministry of Technology, to get the information it wants.

So that there are already three methods at our disposal. N.R.D.C. mainly for inventions; the Ministry of Technology, through the Industrial Group, for longer period investment; and I.R.C. for matters mainly involving mergers and rationalization.

Then the Ministry of Technology is piloting through the House of Commons a new Bill, the Industrial Expansion Bill, to give the Government greater power to intervene in a big way, where it is in the national interest to do so; such as in the aircraft industry, which is always wanting money, or in shipbuilding. So eventually there will be a fourth mechanism. All these methods are directed towards improving the efficiency of industry, and so of our exports, and so to reduce our balance deficiency.

In my view, improvement in the structure of British industry is one of the most important tasks. This rests on the view that there is a minimum size of firm, or, if you like, an optimum size of firm, for a particular product. In a memorandum written for the British Select Committee on the House of Commons on Science and Technology, I have given the arguments in some detail. An essential part of the argument is that in the field of rapidly changing science-based industry, where strong R. and D. teams are essential, that there is a minimum size of firm in order to be able to earn enough profits to pay for the R. and D.

One can waste a lot of Government or private money by tackling technological problems with too few resources. Just as in war if one attacks the enemy trenches with too weak forces one suffers losses and make no advance. The speed of movement of modern technology is very great. The computer industry is a notable example of the necessity of large size of firms. The Ministry of Technology is to help bring into being firms that do satisfy these conditions and that are likely, if well managed, to make the grade as internationally competitive.

To sum up, once you get away from pure science, which should be done mainly in the universities, the expenditure on R. and D. directed to increasing wealth is so great that it is necessary to become very cost-conscious. R. and D. for its own sake can be a waste of national resources. In general R and D must be integrated with the subsequent steps of design, production and sales. You have to see things right through from research to the final sales. Research is only one very small part of the total field of innovation. The classic chain, called the innovation chain in research and development, is: applied work, invention, development, prototype design and construction, production, marketing, sales and profit—all the way through, before you get a profit. The earlier stages cost money, and the latter stages make it.

One of the problems in countries like yours and ours where we have a great deal of R. and D. in Government stations, is to make the transfer from R. and D. in Government stations to the final manufacturing stages in firms. The latter stages may cost ten times more than the early stages. The research and development is the cheap part of it.

Where we have perhaps made some mistakes in England is in by doing a great deal of research and development, but not following it up properly by making the transfer to the manufacturing side of industry. So, to get a realistic return on our money it is necessary to see the whole process right through from the research and development and rough sketches until the project is completed and the product sold profitably.

We are canalizing more and more of our interests towards the latest stages of the innovation chain, whereas in the past we canalized it rather towards the early stages.

If I may say a word about your country, I think you are already facing two of the main problems which face Britain: the problem of transfer of R. and D. from a Government station to manufacturing industry, and the selection of firms to receive aid.

The Chairman: Thank you very much, Professor Blackett. I will ask Senator Cameron to open the question period.

Senator Cameron: Professor Blackett has given us a very interesting and stimulating summary of what is being done in the United Kingdom. This information comes at a time that is vital for us, because we in Canada are just getting started.

I would ask Professor Blackett what are the criteria used in the selection of companies to which Government funds for research are going to be directed and, second, how would the competing industries, which are not receiving assistance, react, and how do you cope with that reaction?

Professor Blackett: Those are two extremely important questions. I think my first answer is that we are rather experimental in our approach to this thing because we have just to try it out and see what happens.

When the N.R.D.C.—National Research Development Corporation—was founded it was argued that this would be impossible to administer because you would have to make a selective choice, and the other firms would object. It did not work out actually in that way.

I think the reason is that in a country like England with firms of different structures and different interests, any type of development usually fits one particular firm more than it does another. One particular firm will have the resources in specialized manpower because of the type of work it is doing. So, it is unlikely that we would find two firms equally willing to take on the project and receive money for it. There was an occasion when two similar projects in two firms were both supported by the N.R.D.C. I think this was a mistake. Luckily one dropped out.

But this is not as difficult to administer as one would expect. As one goes on one watches one's step. The people administering it have to have a very intimate knowledge of the psychology of the particular firm they are considering, and the other firms. If it was a question of giving a grant once and for all, and never more, then it would be difficult, but what happens is that firm A asks for support for project X, and the N.R.D.C. might say: "We will give you a million pounds on certain terms". Another firm comes up with a similar project and says: "We want a million pounds", but to that firm you say: "Well, we have already made up our minds on that one, for good reasons or bad. You think out the next project and come up next year with another one." If it is a continuous process then everything is fairly all right.

The Government announced about two years ago that it had given five million pounds to I.C.T., a computer firm, over four years. That had a very good effect on the firm. The other companies did not grumble. One other company applied for money, and then withdrew its application. Another firm applied, and got some money for a different thing.

So when it comes to the point, the difficulties of selection are not as great as you would expect. They could become great in certain circumstances. Of course, there are many people in Britain who talk about the bad effects of selecting firms in that way, and the point that everybody must have an equal chance. I am convinced that often one has to make a selection. It is impossible, in my view, to get the results you want by simple non-selective financing of all desirable R. and D. We have not enough resources to do it. We can rely always on Parliament telling the Government, by means of awkward questions, when it makes a mistake. But, in fact, they have not arisen nearly as much as might be expected.

Senator Cameron: Related to that, you referred to mergers and rationalizations, and you quoted the Leyland Motor Company as an example. Was there much resistance to that reorganization?

Professor Blackett: I was not in on the details of that, although the Ministry of Technology was. I think the objection to mergers was one arising out of conservatism, because these mergers do mean a displacement of top personnel. They are not accomplished painlessly. We hear about the trouble of the operatives who are thrown out of work when a factory closes, but this is also true of the top level of management. The people there may lose or have to change their jobs too. It meant difficulties, I have no doubt, for persons like Sir Donald Stokes and Sir George Harriman, for instance. Those matters are not to be overlooked. They pose difficult problems.

There was the A.E.I./G.E.C. merger, which raised many hackles because of the way it was done: but I am sure that that was in the national interest. The Ministry of Technology supported it and the Industrial Reorganization Corporation (I.R.C.) supported it. It meant a total reorganization of the top managerial structure. The R. and D. is being concentrated in the Midlands. There were many changes which were not at all painless, and nobody thinks that they are painless. The great fragmentation of British industry must be dealt with and this must be painful.

There was one classic case, for instance, of eight companies making high power electric transformers, whereas in America there are four, and in Germany there are three. How can you compete abroad under those conditions? That number is now being reduced, and the I.R.C. is playing a part in it. We just cannot afford to spread our money and resources of qualified scientists and engineers (Q.S.E.s) so widely. We have not got enough Q.S.E.s for so many companies. So merging is one way of accomplishing several things.

Some of the advantages of merging are seen in the increased length of runs which can lead to more efficient manufacturing process, the better use of Q.S.E.s by putting them together in viable teams, and the advantage of better management.

Senator Carter: I have two separate questions, but before I begin I should like to put one more question along the line of those posed by Senator Cameron. In selecting industries for grants do you select subsidiaries of American companies as well as British industries?

Professor Blackett: This is a point that I do not think has arisen yet, although it obviously will arise. Certainly it is being discussed, and has been discussed. Frankly, I do not know, but my answer would probably be: 'Not at the present moment, except in exceptional circumstances.' In some circumstances I would say: 'Certainly, yes'.

On the whole, American investment in Britain has done Britain a very great deal of good. It has brought in capital, and it has brought in managerial know-how on a very big scale, and that cannot be despised at all. There is no hostility to foreign-owned companies, provided they do not dominate the scene too much, which is a problem you have to face here much more urgently than we do.

Senator Carter: My main question is: are you, in Britain, thinking in terms of what I might describe as protecting yourselves from the imperialism of United States technology, which has tremendous resources...

Professor Blackett: Tremendous.

Senator Carter: ...compared with your resources?

Professor Blackett: Yes.

Senator Carter: The same is true in Canada.

Professor Blackett: Yes.

Senator Carter: In the States with their space programs they are exploring fields to enable them to develop all sorts of alloys and new products which one cannot even contemplate. What are you doing to offset that? Are you just restricting your programs to a limited scale? Are you taking it for granted that you will have to import their technology anyway?

Professor Blackett: You have to import a great deal of technology. Britain produces probably not more than 10 per cent of the total technology of the world if you add it all together, and it would be ludicrous to try to live only on that amount of technology which you have made yourself. For every country other than the giants—and even the giants have to import technology—the question is how to import it. To import manufactured goods in bulk is the most expensive way in foreign exchange. To get a licence costs, say, 10 per cent of the foreign exchange. Alternatively one can buy know-how. There are thus various ways, but every country which is not a giant has to face up to this fact and make some arrangement to use both foreign inventions and developments within their own institutions.

It must be remembered that the money made out of inventions is very often made not by the inventor but by the next one along. The Bell Telephone invented transistors, but it was the Japanese who really went to town on them in relation to the consumer industry, television supplies and things like that, because they exploited them better and quicker. The fact that something is invented abroad does not mean you cannot in fact use it. There are many ways in which our own industry is independent commercially but in fact uses foreign technology, not only American but very largely American technology. This is inevitable.

Senator Carter: I may not have expressed myself as clearly as I intended. What I was thinking about was this. It is a fact that you must have this technology, but since your program is geared to industry, your balance of payments and exports, are you concentrating on fields which will not be exploited by the giants in those fields?

Professor Blackett: This is what we would like to do. We have not developed a very consistent way of doing it because the economy of a country is a very complex thing. There are many firms in it and we are gradually formulating a policy to deal with that. We have made a national decision that we want to keep, if we possibly can, an indigenous computer industry, and we have put a lot of government money in it. We have also considered micro-circuitry, though we are still negotiating what to do about it. All these things involve tens of millions of pounds of government help one way or another.

You cannot have everything, so we are selecting certain key industries and saying we will support them if they can prove a need. I do not think we have yet said clearly that there is an industry we will not support, but there are perhaps many that we would not support when it come to the point. There are no fundamental principles here. We have the objective and we have to play it by ear. As I say, we are trying to strengthen the growing points, trying not to throw good money after bad but to throw good money after good and build up really strong teams. In the process of a year or two, perhaps half a decade, we will probably have from experience a philosophy on what firms are worth supporting.

Senator Carter: I was thinking about your missile career in respect of which you have dropped out of competition, and your Concord which you were building with France but which is now suspended, the technology of which it seems may be lost as well. We had a similar experience with the Arrow. You yourself emphasized the importance of costing because the later phases are so much more expensive than the earlier ones. I was wondering whether you were thinking of doing one of two things, either teaming up with European countries to pool resources on specific projects so that you would be more comparable with the giants, or just selecting a field.

Professor Blackett: It is official policy to try to combine with Europe in the industrial field. This means co-operation between Britain and European firms. On big projects like aeroplanes, the Government must of course come in. The Plowden Report suggested that we should never again build another major civil airliner because the launching costs are too heavy to be borne alone. So it is now assumed that we do not go in for any big aircraft except as a joint venture with one or more other countries. It may not be a very efficient way of doing it, but it is happening and certainly technologically we are doing it very well.

The general political wish in England is to go into the Common Market—which we are not likely to do for some time yet, but it is still our policy. In the meantime we have lost interest in combined projects, and there are many discussions in progress on how we can co-operate abroad. However, when it comes down to manufacturing in industry, it must be co-operation between firm and firm; you cannot easily collaborate between government and government on manufacturing motor cars, etc. Joint companies are a good way of doing it.

Senator Carter: I have several other questions, but there are others who want the chance to ask something. Perhaps I might be given another opportunity later.

Senator Grosart: Professor Blackett, I know you are aware that we are not a unitary state in Canada; we have a degree of political fragmentation which probably more than matches your industrial fragmentation. Could you give us some idea of the scope, jurisdiction and power of authority of the Ministry of Education and the Minister of Technology in their respective fields? Are there any limitations on their power to do these things?

Professor Blackett: I am afraid I cannot say very much about the Ministry of Education because I do not rightly know the niceties of the relationship between the ministry and local education authorities. The ministry budget covers the school budget but the ministry does not, I think, actually spend it; in detail it is mostly done locally and I am afraid I would not know exactly how it works, I am sure you have a similar situation with federal money which is spent locally. The budget for the ministry may be over $1,000 million, but the amount they actually spend is quite small. It is the same in the medical field. The hospital systems are run by local boards so that although the budget is high it is not actually spent by the central authority, and one would have to be an expert in these fields to make any useful remarks.

With the Ministry of Technology we are in the very early stages of growth and do not really know what the limitations of our actions are. We are creating them as we go along. The idea for the I.R.C. arose in the Ministry of Technology; but administration is now under the D.E.A. In the new Expansion Bill, Ministry of Technology is creating a tool for supporting industry when it is necessary to do so. As we find the existing tools inadequate we try to create more. There is no rule imposed on us from outside; we are inventing the rules tentatively. Mistakes will be made. Take, for instance, micro-circuitry, whereby a complex set of transistors are produced on one area the size of a pea. Everybody knows they will revolutionize radio communication. The United States is some two years ahead; helped by large government orders for Defence and space programs. How can we in the U.K. create a viable micro-circuitry industry? One is told that it would be fatal to drop out because to drop out of micro-circuitry is really to drop out of much advanced electronics. Because each circuit is designed for a particular job, there are four or five firms in the U.K. dabbling in it, none on a very big scale, and probably losing money. Have we in the U.K. got power, and what sort of power, to push them into a viable group? Well, we will have to see. It depends very much on what these firms themselves like and want. So that we are working ad hoc from hand to mouth with no clear-cut recipes.

Ministry of Technology has attempted to survey the position of many industries and see if it could do something to help them. It has not made detailed statements about all it would wish to do. It is very much a question of finding opportunity targets to help. When a firm needs help in some technologically advanced project, the Ministry of Technology can often help.

Senator Grosart: Are you running into any strong resistance—academic, philosophical or practical—to this degree of state enforcement of bigness?

Professor Blackett: Yes, quite a lot, but I do not think it goes very deep, if only because some large parts of British industry such as the aircraft and electronics industries receive heavy government support. Some industrialists disapprove of this but seldom in the case of their own firm being helped. We find that an enormous amount of money has been spent on financing the Concord. Some industries which want money do not object to it. Some industries which are traditionally not in need of it take the ideological view that it should not happen. Various industrialists opposed the creation of the Industrial Reorganization Corporation—in fact it has been an extreme success; everyone agrees it works. I agree that government aid can be carried too far, to the point of wasting government money and perhaps harming a few. In fact, by and large, the firms who need it are pleased to have it. So I do not think the opposition is very deep. Industrialists realize that if the U.K. is spending £1,000 a year on R. and D., let us spend it properly. They naturally want to maintain freedom for industry, they realize that some aid is needed. So they are beginning to realize that Ministry of Technology is out to help industry.

Senator Grosart: Two of our major granting bodies, the Canada Council and External Aid, have told us they work really on a response basis. That is to say, they respond to a request for specific aid. Is this the policy of the Ministry of Technology? Or do you actually go out and survey the field and say "Here is a project which needs to be undertaken, we will find the people, and we will push this on?"

Professor Blackett: Both happen, but you are quite right. When they make an arrangement so that the firm comes and asks a government agency for aid, it is in a very much stronger position: it can make its own terms, and can always reply to other firms "Why don't you ask for aid?" Of course, a particular project may start with a lunch at the Athenaeum, where it may be suggested "Why don't you ask us for something?" Then it comes in as a request, "Will you help us?" It is better this way than the other way around.

It may all start by a survey of the industry, to find out the good and bad points. One may find out where there are great deficiencies in certain parts of industry, and point them out to the relevant firms. It may end up with a firm asking for help.

Senator Grosart: To be specific on that, you mentioned eight firms in the electronics industry—

Professor Blackett: In the heavy electrical.

Senator Grosart: The heavy electrical equipment industry. You say that the number has been reduced?

Professor Blackett: Yes.

Senator Grosart: In this case, did the Ministry of Technology say that eight is too much? Is that how it started out? Or did some of the firms get together and agree that it was too much? Where was the initiative, the major decision to limit competition in the national interest?

Professor Blackett: It is a bit complicated, because the existence of the eight firms compared with less than half the number in U.S.A. or in Germany was very much mixed up with the purchasing power of the C.E.G.B. —the Central Electricity Generating Board —which is a Government corporation.

They could, by altering their purchasing, effectively reduce the price. It was found that the industry were not doing much about it. I think the C.E.G.B. till lately tolerated the existence of so many firms and spread around its orders.

Now they are beginning to aim at reducing the number. There is a body called the N.E.D.C., the National Economic Development Committee, set up by the Department of Economic Affairs. This body pointed out their fragmentation and helped to bring about the changes necessary to reduce the number of competing firms.

Senator Grosart: I have one final question, Professor Blackett. You mentioned the fact that one of the means by which the minister encourages new development is by the use of its purchasing power: that is by ordering some novel project from some firm. How does this work out, quantitatively and qualitatively?

Professor Blackett: We do not do this very much in the civil field, but often in the defence field.

In the civil field we have nationally great purchasing power, but we have not mobilized it very successfully to have a large influence on technological advance and on the efficiency of management. In computers we have succeeded in doing this to some extent. The Government as a whole, spends, I believe, over £5,000 million a year on Government purchases. To use the power that this gives to rationalize industry has certainly been an objective for some years now, but it has proved hard to carry it out.

Senator Cameron: Roughly what proportion of your budget is spent on the aeronautical and electronics industries?

Professor Blackett: I do not remember the amount spent by the Government but I do remember that in the aeronautical industry, research and development amounts to 35 per cent of output, and in the electronics industry about 13 per cent. With most other industries the research and development is less than 5 per cent.

If our total R. and D. budget nationally—from Government and private enterprise—is £1,000 million, I suppose £400 million would be defence. I have forgotten what it is exactly. I think it is in some of the documents. I know it is a very substantial amount.

Senator Cameron: Relating to that, a lot of our technology of private industry has come out of defence research.

Professor Blackett: Yes.

Senator Cameron: What is the time lag allowed between the discovery of a new principle or element, and the time it becomes a commercial venture? In some cases it is ten years and in others five years? Is the time lag between discovery and application being shortened substantially?

Professor Blackett: This is a very important point. When you have a really basically new discovery, it is often very long. In the case of transistors, however, it was rather short. The N.R.D.C.—National Research Development Corporation—which deals with inventions, has to work very quickly. If it goes too slowly your competitors can get all the advantage by manufacturing quickly. So what has come to be called the "lead time," that is the time between the beginning of the project and the start of sales, has to be kept short. Very often it is necessary to have big terms on a project in order to keep the lead time short. If one goes too slowly, it becomes too late. In the U.K. I think we are apt to put too limited resources on too many different projects and so we are going too slowly on all. So it is a very important consideration when one is dealing with something like a new computer or a new transport vehicle, that adequate resources of money and men are deployed so as to get it through quickly. For instance, it is very relevant for hovercraft because, though there is now a novel and patented idea, still other countries may find ways around the patent. So if one takes too long exploiting an idea, other people will do it first. Speed of exploitation is therefore very important, and that means having a clear understanding of the resources necessary to get ahead quickly.

Senator Aird: Mr. Chairman, may I refer Professor Blackett to a paper by the Right Honourable Anthony Wedgwood Benn, M.P., Minister of Technology. I am sure you are familiar with this paper, sir. Mr. Benn also referred to the question of viability. Just relating this idea to Senator Cameron's question, is this what he is talking about when he mentions viable interests? He says:

> The choice for us, it seems to me, lies between allowing these American corporations to pick up our growth points and integrate them as lesser parts of their own empires; or to start building viable units first on a national, then on an international basis so that the companies that emerge are truly international in character and are not solely extensions of American industrial power with all the political implications that that would have.

I realize that you have been talking about viable units, and I presume this is the line of answering that you are making, sir. But Mr. Benn goes on in the next paragraph as follows:

> Just as we are now having to reconstruct our schools, our legal system, our local government, regional government, civil service and parliamentary system, to cope with the development of technology in Britain, so we must find new institutions capable of giving us some say over our own personal and industrial destinies in a period when global decisions about all these things could easily be made by the self-perpetuating hierarchy of some non-elected Board of Management in Detroit...

and so on.

Is there a distinction between these two?

Professor Blackett: I do not think so. I think a concrete example is the computer industry. The idea of a digital electronic computer arose in Princeton during the war, and then Britain went ahead fast and, I believe, was the first to export manufactured computers. For a few years the U.K. exported more computers than it imported. However later the British computer industry almost went bankrupt. Our failure was partly because there were too many firms for the market. The industry made good computers but could not sell enough of them. The British computer industry nearly died by having poor national management. Then one firm, International Computer and Tabulation—I.C.T.—came into being by the merging of the computer side of three other companies. The Government aided it financially and now it is a viable concern with 30 per cent of the British market and 30 per cent exports. Though it is doing well, it is still vey small compared to I.B.M., International Business Machines. I.C.T. produces about one or one and a half computers a day; I.B.M. produces 35 computers a day. This shows the scale on which computer firms must operate. Can our computer industry, as it is, be viable? Probably not as at presently organized. As Anthony Wedgwood Benn suggests, we could improve still further by linking up with the European firms and possibly even with some American participation. That is the way he is thinking. But I think we are all agreed that we must have strong viable national units if we are to make satisfactory arrangements with European firms. This is the rational way to proceed, I think. I use the word "viable" very much as Anthony Wedgwood Benn does.

Senator Roebuck: I would like to know, Professor Blackett, what you do with regard to patents? Take your pure science, for instance, which is supported entirely by public money and universities. Do you allow the university itself to patent a new idea, or do you allow the individuals who discover the ideas and develop them to patent them and protect them against others? Then, again, what is the policy with regard to an idea being in private hands? A patent, of course, is a restrictive document and prevents the use of the idea except when it is paid for, but still it is restrictive.

Professor Blackett: Oh, yes, it is.

Senator Roebuck: In some universities in the United States the universities themselves patent a great many ideas and the individual is sometimes given something for his work.

Professor Blackett: Yes.

Senator Roebuck: And in other places the individual himself is allowed to take out a patent. What do you do in England?

Professor Blackett: That has been greatly discussed by the National Research Development Corporation—N.R.D.C.—because it exists to deal with inventions. It has a sophisticated patent organization. In many cases a university's lecturer or professor gets N.R.D.C. to take out a patent for him. Any money coming out of it can, according to the circumstances, be split between the universities and the patentee himself. In the case of the F.C. Williams' invention which led to the original Mercury computer, the large sums that were involved were eventually split between the inventor himself and Manchester University on the ground that the invention had been made in the university, on the university's time and with the university's equipment, even though in fact it was essentially an invention by one man. In cases involving smaller amounts, the universities might not ask for a share, but this particular case involved big money.

So practice may be slightly different in different universities, but on the whole the patents are taken out either by the individual or by the N.R.D.C. on his behalf. Even though the individual can go to the ordinary patent agent and have his idea patented there, only a few do. Most of them make use of the admirable patent service of the N.R.D.C. One advantage is that if the product looks good the N.R.D.C. has the funds necessary to exploit it. In this way exploitation follows the taking out of the patent.

Senator Roebuck: It is not up to the individuals to decide that?

Professor Blackett: Except rarely; they are not in a position to exploit their ideas. They have not got the resources. In America it may be possible to do so, but in England many do not know much about industry or have access to finances, and so they do not know how to set about development and manufacturing. The N.R.D.C. is for that purpose.

The Chairman: We will adjourn for 15 minutes.

(Short recess)

UPON RESUMING:

The Chairman: Well, now, next question, please.

Senator McGrand: Dr. Blackett, you mentioned earlier about a merger of large firms resulting in the loss of jobs at the top level.

Professor Blackett: Yes.

Senator McGrand: This also occurs in science?

Professor Blackett: Yes.

Senator McGrand: And as well as the lower level of employees. Now, are these people re-employed in Britain or do they enter the brain drain to the United States?

Professor Blackett: I don't think we know that and I doubt whether very many of the high up people join the brain drain. A lot of the young people do. This is very serious particularly in the engineering field. This movement is going on all the time. It is, of course, part of the free enterprise system, but I have not heard of any spectacular cases of the top people emigrating as a result of a merger. Nevertheless, I am sure there must be some.

Senator McCutcheon: Perhaps if they are not good enough to stay there may not be that much of a brain drain involved.

Professor Blackett: Thank you very much for the confidence you display in your remark.

The Chairman: I would like to ask you a question about something you said earlier in your presentation. Am I to understand that what you call mission-oriented research is done exclusively within the Ministry of Technology? For instance, are the research councils which are within the Department of Science also engaged in mission-oriented research as well as pure research?

Professor Blackett: Thank you very much for bringing up a point with which I wanted to deal. The research councils do support applied research in the universities, but it is mainly basic applied research such as in mechanical, electrical, civil and chemical engineering. Sometimes work goes on directed toward a particular project, but more often it is rather more general. It is "applied" in the sense that it deals with the fundamentals of engineering and so is directed ultimately toward concrete national objectives. Pure science is directed toward increased knowledge.

The research councils do make grants to universities for applied work as well as for pure science. We encourage universities to do more applied research. We in England have been extremely good at pure research but we have not been so good at applied work. We believe pure research should generally be done at the universities.

The Chairman: But the research councils do not have laboratories of their own?

Professor Blackett: Yes they do! But mainly pure research laboratories like the Rutherford Laboratory in high energy physics or in astronomy. The institutions of medical and agricultural research also do much excellent pure science.

The Chairman: Then coming back to my question: is mission-oriented research the exclusive responsibility of the Ministry of Technology?

Professor Blackett: I think that the majority of mission-oriented research financed by the Government is the preserve of the Ministry of Technology, but important amounts are taken care of by other ministries.

Senator McCutcheon: Are there any other government departments which conduct research?

Professor Blackett: Yes, and this is very important. Building research used to be carried out by the old D.S.I.R., but it has now been taken over by the Ministry of Public Works and Buildings. Likewise the Road Research station has been taken over by the Ministry of Transport. This is a controversial question and there have been strong views expressed both for keeping such stations in the Ministry of Technology, and for putting them in the ministry directly concerned with the work they are doing. My own view is strongly towards the latter. Thus in my view it is better, for instance, for road research to be in close touch with the Ministry of Transport even though this may mean less contact with other scientific stations.

The Chairman: But at that stage surely this is really purely development work?

Professor Blackett: Yes, mainly development work. Then of course there are the big laboratories under the national corporations. There are, for example, the Coal Board, the Electricity Board, the Gas Board and now the Steel Board. They have very big research laboratories of their own. For instance, the CEGB is doing quite a lot of applied nuclear work related to the technology of the Nuclear Power Reactor, which it orders.

Senator McCutcheon: What about agriculture?

Professor Blackett: The Agricultural Research Council (A.R.C.) has its own stations and comes under the Department of Education and Science and not under the Ministry of Agriculture and Fisheries. Similarly the main medical research comes not under the Ministry of Health, as you might think, but under the Medical Research Council (M.R.C.) under the Department of Education and Science.

There are four such councils, A.R.C., M.R.C., S.R.C. and N.E.R.C. The A.R.C. has many stations and includes one very famous one at Rothamsted.

The M.R.C. has also a big and famous laboratory in London and about 80 smaller units mainly on university campuses. The S.R.C. provides most of the finance for research in universities and associated stations. The fourth, the N.E.R.C., National Environmental Research Council, deals with geology, oceanography, and some aspects of meteorology. They also deal with conservation problems and problems involving the countryside and its environment. Then four research councils have clearly defined fields. So each one can know its own field intimately and in detail and so can distribute its grants wisely. I would point out that these research councils are all statutory bodies; the personnel are not civil servants. They all come under the Department of Education and Science. There is also the Council on Scientific Policy (C.S.P.) the chairman of which is Sir Harry Massey. This council advise the Secretary of State on the general problems of the research councils, what their budgets should be, in other words the size of the cake and how it should be divided. The C.S.P. is purely an advisory body but its views go direct to the minister. But the research councils themselves, within their own budgets and the general rules laid down, can spend the money as they like.

Senator McCutcheon: You are speaking of budgets—what money is involved in their budgets?

Professor Blackett: The four research councils are spending about £80 million a year, of which about half goes, for example, to the S.R.C. Despite the squeeze going on at the present time the budget is increasing at over 8 per cent per annum at a constant price.

The Chairman: Is it true that the Ministry is envisaging creating a new council for the social sciences?

Professor Blackett: It already has done so. This is not one of the four councils I have mentioned. It belongs to the Ministry itself. It is called the Social Science Research Council (S.S.R.C.). Michael Young is the chairman of it and it is starting to find out what are the needs of the Social Sciences and what subjects the Council should support in a systematic way. This is something that has never been done quite in this way before. It used to be done in a small way by the DSR. So now the United Kingdom has five Research Councils. I think the S.S.R.C. is a good idea, but it is too early to say how effective it will be. I think it will take a year or two before we can judge that.

In natural science it is fairly easy to judge each other's capabilities and assess what is good and what is bad, and so it is reasonably easy to allocate money fairly. In the social sciences it is sometimes more difficult to get an assessment of the worthwhileness of projects. This is because some of the social sciences are rather young and so criteria of rightness or wrongness are not so easily arrived at. This does not mean that social sciences are not good, but it is a more difficult subject to make judgments in than the exact sciences. I think everybody would agree with that. You know the old crack of the 1930s: When you hear four economists talking together, you find five opinions, and two of them are Keynes'.

Senator Grosart: Professor Blackett, are these counter-fragmentation remedial policies applied vertically as well as horizontally?

Professor Blackett: I think that there are no firm rules in the movement towards mergers: in fact, the United Kingdom is playing it by ear. There is little literature and little doctrine. The books by Stacey and by Catherwood give some useful facts about mergers. There is no authoritative textbook on how to behave. At the moment the Government would, I think, support a merger, horizontal or vertical, as the case may be, if it thought it would lead to greater productivity and export. The industrial structure is various, and it might sometime be more important for, say, an instrument manufacturer to team up with a firm making components, rather than to team up with a manufacturer making the same product.

The Chairman: What about difficulties which might arise from those who are responsible for your monopolies legislation?

Professor Blackett: The Government was ragged a lot about simultaneously introducing a stricter monopolies bill and the Industrial Reorganization Bill to encourage mergers, which the former bill was supposed to stop. However, it has not worked out to be so contradictory. The Board of Trade has been very sensible. As far as I know, no merger recommended by the I.R.C. or the Ministry of Technology, has been turned down on monopoly grounds by the Board of Trade.

The Chairman: Would there be consultations?

Professor Blackett: Yes. I think the doctrine which came in four years ago has made a difference; that is, if you are facing foreign competition in a big way—like from I.B.M. and Honeywell in computing—then you can only afford one firm to fight it; you need not worry about monopoly as long as you allow the foreigners to compete. If we allow foreign competition, then one is enough. A single British firm does not have a monopoly if American firms are in the United Kingdom. You may be the only company in England yet have only 40 per cent or less of the sales. Britain can only afford one or very few firms if we are to compete successfully with foreign firms.

Senator Aird: It seems to me there is a great deal of planning flowing into these conclusions, and yet you say there are no established targets of aid to industry or for research and development. It seems to me that there should be targets rather than an *ad hoc* policy, as such.

Professor Blackett: I could not agree more. I am not privy to the inside proceedings of I.R.C. and other bodies, but as far as I know, nowhere in ministerial statements or anywhere else are there clear-cut criteria for good or bad mergers.

Senator Aird: It seems clear that this is an area that England should be advancing in, as you pointed out in your opening remarks. There is a high percentage of revenue being expended on research and development, and yet their productivity has not increased accordingly, but to conclude that in the area of industry it should be *ad hoc*...

Professor Blackett: I did not say it should be; I said it is.

Senator Aird: Oh, I see.

Professor Blackett: The Ministry of Technology has set up in A.E.A.—Atomic Energy Authority—a program evaluation unit, under Dr. John Adams. They are looking at criteria for projecting and evaluating technological investment, how you recognize the good from the bad, and what return you can expect to get. It has an analytical, economic approach, done in collaboration with the Economics School of Manchester University. They are tackling it at first in a rather general way, but it has not as far as I know got to the stage where there are ready-made formulae. I do not think that any ready-made formula could be used to solve the problem as to how the United Kingdom can create a viable micro-circuitory industry. It is complicated and mixed up with personalities, etc.

Senator Aird: I agree, but it seems there are general target areas.

Professor Blackett: Yes, in the electronic industry, the computer industry, the micro-circuitory industry and telecommunications, there are general plans as to how we go about it.

Senator Grosart: Has there been any legislative relaxation in the official combines philosophy in Britain?

Professor Blackett: I think there has been some, especially bearing in mind the point I made in answer to the Chairman's question, when, like in computers, like in micro-circuitory, you are faced with very heavy foreign competition, very often manufactured in England, then it is sensible to have one big, competitive firm. In the old days it would have been a monopoly, but now it is not considered a monopoly because there are foreign firms in such strength; so, in that sense, there has been relaxation.

Senator Grosart: How many decisions—if you like, bureaucratic decisions, in the best sense of the word—are related to legislation? I know you are not saying no one cares about the law.

Professor Blackett: I do not know enough about how the Board of Trade Monopolies Act is administered; but, in effect, as far as I know there has not been any clash, such as people expected to happen—that is, when the Ministry of Technology and the I.R.C. might say, "We think it essential that firms 'A', 'B', and 'C' should join together," and the Board of Trade does not often say no. As far as I know, that has not happened, but there had been a fear that it might happen. There must be give and take on both sides.

Senator Grosart: What about the law itself, is it invoked at all?

Professor Blackett: I do not know the terms of the Monopolies Act. You would have to get an expert on company law to answer that.

Senator McCutcheon: You did not meet in your monopolies legislation the extremes we have in Canada and the United States.

Professor Blackett: In the United States legislation there is the paradox, to the pure amateur, that they have the toughest monopolies legislation and, at the same time, the biggest near monopolies—or so it seems to the public.

The Chairman: Legislation regarding monopolies in England is not based on the Criminal Code like ours is. In the United Kingdom, all these arrangements, I believe, have to be appraised ultimately in terms of the public interest and not necessarily as to whether competition has been eliminated or not, as we do here in Canada. So, from that point of view, I think their legislation is more realistic than ours.

Senator Carter: I would like to ask, Professor Blackett, what kind of liaison you have with the Department of Defence, and how you channel the technological overflow from research done by defence into industry itself?

Professor Blackett: The formal relationship is that the Ministry of Defence state their requirements, which could be an aircraft or a certain sort of rocket etc, and they pass it down through the official channels to that part of the Ministry of Technology, which was previously the Ministry of Aviation. The project is then studied: design studies are made and when agreement is reached they contract it out either to their own stations or a contract to a firm in industry. So, when the Ministry of Defence state their requirements and are prepared to pay for them, the Ministry of Technology carries out the work. It is very similar to the relationship with the Ministry of Defence which used to exist when M.O.A. was separate. The question of the civil aspect of the Defence Research Stations, particularly R.A.E. at Malvern and R.A.E. at Farnborough are much under discussion. We are trying to get more attention paid to the civil aspect of the defence work going on there. Some steps have been taken at Malvern, quite promising ones, and at R.A.E. This is a beginning, but this is not easy to do. So far we cannot say we have had many outstanding successes, but on the whole the movement is the right one. We are trying to put these stations that do have civil development work directly in touch with firms which want to use it, so that there will not be any transfer problem.

Some work that has been publicized is that done at Farnborough on carbon fiber plastics which are extremely strong and which are beginning to be used in jet turbines and things of that sort. They are carbon fibers made in a special way and impregnated into high temperature resistant plastics. This looks like a very important material for the future. It is being worked out jointly by R.A.E., where it was invented, and Harwell, together with Rolls Royce and other firms.

Senator Carter: Can you tell us something about your nuclear reactor program? Britain pioneered nuclear reactors, I believe. What is the position now? Is your productivity too low to enable you to compete, or are you competing internationally?

Professor Blackett: No.

Senator Carter: What is happening?

Professor Blackett: It is a long story, and I am not wholly competent to deal with it. The first action the Select Committee of the House of Commons took was that of investigating the nuclear power industry, and there is a huge book containing all their proceedings. It contains a lot of interesting material.

To put it shortly, we have done a very good technological job. We have done good work introducing nuclear power efficiently in Britain. We are producing more nuclear power for the Grid than any other country in the world. But, our reactors do not seem to be saleable abroad. We sold two in the early days, one to Italy and one to Japan, but the Americans, who at the start went much slower—and deliberately so—are going in for a very big program of operational power stations; moreover they seem to be getting most of the export orders for their two types of reactors—the boiling water reactor and the pressurized water reactor—which are quite different technologically from ours, the advanced gas cooled reactor. We have been technologically successful, but exportwise not very successful.

This situation has caused a very great deal of discussion in the U.K., particularly on the relation between the consortia and the A.E.A. the published material is quite voluminous. The problem is highly complicated and is a difficult one to summarize, and I would not be in a position to make any value judgment about what ought to be done. Everybody is agreed that this is not quite right.

Senator Carter: You do not attribute it to low productivity?

Professor Blackett: Not only low productivity in the ordinary business sense. However, it is said that the civil engineering part of a reactor costs twice as much in the U.K. as it costs in America.

The nuclear stations that we have are very suitable for our own Central Electricity Board's requirements—namely, big units with a very heavy base load. But they do not seem to be so suitable in smaller sizes and most of our possible customers do not want such big ones. The Americans have won out against us commercially, I am afraid, although we have at present by far the biggest production of nuclear power in the world.

Senator Carter: How much does it cost to produce power from nuclear reactors as compared to the cost of producing power from other sources?

Professor Blackett: Comparisons have been made and published. The key point of the thing came up about two years ago when A.G.R. was being assessed by the Central Electricity Board, and a comparison made between them and oil-fired generators and the American-type of nuclear reactors. Such assessments are not simple to work out, because the answers are dependent on many factors including the discount rate assessed it might depend upon one type thing being more capital-intensive then others. I have read that the American designs are cheaper in respect of capital, but are more expensive in terms of running costs, whereas ours are the other way around. Countries that are short of capital prefer the capital-cheap reactor. But, the differences seem to have been small, calculations were published, which showed that the A.G.R. stations that will come on to the line in the U.K. in 1972 or so will produce electricity that is definitely less per unit than that produced by the corresponding oil-fired station, which are fractionally less than that produced by the American nuclear reactors.

But, as I say, there is a good deal of disagreement about the basis of these assessments, because they depend upon the relative price of capital and the other ground rules for the calculation.

Senator McGrand: Is industrial research in the United Kingdom related in some way, or in any way, to the research carried on by members of the Common Market? What I mean is: Is there a co-ordination of effort?

Professor Blackett: Well, this is enormously under discussion at the moment. The idea of a technological gap has been voiced in Britain, and in Italy and elsewhere. Everybody is trying to discover whether action could be useful. A lot of talk is going on about trying to get co-ordination of programs at the basic level. We collaborate, of course, in pure science and in high energy physics, and in space, and perhaps in a number of other areas. But, when it comes to real industrial programs, you cannot really get very far on a government-to-government basis. You have to get to a firm-to-firm basis.

I do not know what is happening, but this is really a matter for the firms themselves. For instance, should the British computer industry combine with the continental computer industry to make it a European corporation? This is a difficult area, because it is not really open to the Government to do very much about it, except to give its goodwill and possibly some financing if it comes off. But, there have been a good many talks about British industries and continental industries. Aviation is a field where co-operation with Europe on a Government-sponsored firm-to-firm basis is going on. Many people would like to see much more of this type of co-operation. However, though we are keen that it should happen, it is not easy to see how.

The Chairman: Is not that a vital element, though, in the whole picture?

Professor Blackett: It is vital, yes.

The Chairman: Because otherwise you might build industries which would appear to be viable on the basis of the individual country, but which will never be able to meet the American challenge.

Professor Blackett: Yes. This has been accepted in aviation. There is no doubt at all about that. We are collaborating in several projects, not only in the Concord with France, but in the air bus with Germany. It has been said that the computer industry is non-viable alone, and it must combine with the continental computer industry, but the Government cannot make a statement like that. It can help to bring that about, but the decision rests with the firms themselves. There is a limitation here on Government action. And we should do something about it. Government can offer encouragement and perhaps substantial financial aid, and hope that it gets going.

The French are having difficulties with their computer program. They had a good substantial firm called BULL, but it got into financial difficulties and was bought up by General Electric of America. There is not now any strong indigenous computer industries in Europe except in the United Kingdom.

France has said, "We must have a computer industry," and they have announced that they are putting a large sum of money, I think I read £35 million to produce a computer industry which will be viable by the 1970s. They have gone ahead. They have said, "We must have it." We cannot compel them to unite with us. They are doing what we are doing, namely, building up a national industry first. When they have got it then perhaps a merger will be possible.

Senator Grosart: Have the Common Market countries made any significant progress in allocating priorities in respect of industrial production?

Professor Blackett: I do not really know, but I would suspect rather little.

Senator Grosart: Yes.

Professor Blackett: I have not any certain knowledge.

Senator Hays: Professor Blackett, how do you handle programs in the field of research that are obsolete, and that sort of thing? Who decides when a program should be wrapped up? How do you prevent built-in programs that go on and on, and are never completed and are not paying, and that sort of thing?

Professor Blackett: My teacher Rutherford used to say, "It is very important to know what experiments to start, but it is much more important to know what experiments to stop." It is a very difficult question in which the owners, so to speak, of the big stations, the government departments controlling them, have a very heavy responsibility. In the past I think that control has been very lax and things have just gone on. Rumour has it that there are cases where nobody remembers why a program had been started: it just went on by inertia. With the big stations it is very difficult to keep control. I do not think it is a major scandal, but certainly there are minor things that should be stopped. The Ministry of Technology is now beginning to put into operation a departmental organization for the control of the policies of the research stations. The Min:Tech research programs amount to about 100 million a year altogether. The proposed organization should bring some sense into the problem of overlap. There is materials research going on in half a dozen government laboratories without in the past proper coordination. That will be coordinated under the new regime.

The Chairman: By the Department of Technology?

Professor Blackett: By the Ministry.

Senator Hays: What about the duplication of programs?

Professor Blackett: That is part of it.

Senator Hays: You are suggesting that a review board may be set up?

Professor Blackett: Yes.

Senator Hays: Whereby they can assess the program from year to year?

Professor Blackett: There will be machinery in the Ministry of Technology which executively controls the programs of the stations, and when a program is drawn up they will make sure there is no undue duplication.

Senator Hays: Are the programs that you support so far as industry is concerned sharing programs, which would probably tend to help?

Professor Blackett: A few of them are shared programs with industry. Too few. We are trying to build this up, but there are too few. Many of them are self-generated within the station. Very often the work is very good. The problem here is that some of the work tends to be first-class pure work. Malvern, which is the brilliant electronic station which did so much of the radar work during the war—and has incidentally gone brilliantly into Radio-Astronomy—has started to do what is wonderful university-type research. It is first-class and is a great credit to the country, but in the long run I think it is in the wrong place. You are therefore faced with the problem of having brilliant pure research done in these government stations, alongside the main applied program of the station: so a delicate hand is needed in running the stations.

Senator Prowse: Is there any central register or catalogue of research so that the people do not start something which may already have been carried on elsewhere in the country or outside the country?

Professor Blackett: That is in fact being looked into and done now. I do not think it was done before. In fact I am sure it was not. There was great duplication in certain fields, but I think that will be put right.

Senator Prowse: Is the possibility of international co-operation on such a registry real or not? What I have in mind is this. Every nation is carrying on research within its own borders and to some extent they can eliminate duplication within those borders if they know it is going on. As far as European countries and America are concerned, is there an exchange of information? Do you anticipate getting information from them on what they are doing and exchanging your information with them so that there will not be duplication in two countries?

Professor Blackett: You mean with America, for instance?

Senator Prowse: With America, for instance, and thinking possibly of Russia.

Professor Blackett: I do not know, but I suspect that in parts of the defence field we have collaborative arrangements with America and exchanged views. In the civil field I should not think so. There is a certain part of that field which deals with things that do not involve the manufacturing industry, such as water pollution, where no doubt there is collaboration across the board with other countries doing it, because it is non-competitive in an industrial sense. On the industrial side I should not think there is a great deal.

Senator Prowse: What I have in mind, and what I have heard discussed, is that one of the important things in research is very often to find out that something cannot be done.

Professor Blackett: Yes.

Senator Prowse: A firm may carry out research and get the answer to that. Then somebody else facing the same situation starts a project, and not until they have finished do they find out they could have saved themselves a lot of time and money if the information had been available to them. I take it it is not available at the present time.

Professor Blackett: I think probably it is available on paper but people are only beginning to do something about it. It is a very complex problem. A great deal of admirable work is being done on materials research in half a dozen stations. To avoid too much duplication is quite a long job and will take time.

The Chairman: So you are envisaging that in future the research effort at that level will probably be more supervised, and more controlled, than it has been in the past?

Professor Blackett: Certainly. There is no doubt about that at all. It will be controlled in two ways at least. One is to stop obvious overlapping and duplication; the other is to get what is done linked as soon as possible with a manufacturing industry. Those are the two main ways we are trying to achieve.

Senator Cameron: Recognizing the increased orientation of scientists throughout the world and the fact that you are a member of the Soviet Academy of Science, are you finding much coming forward from them to yourself, or is there a sharing of some of their technology with our people? In this country we are getting some benefit from the northern research in perma-frost and forestry work. I am wondering how extensive this co-operation is.

Professor Blackett: There is a great deal of collaboration on pure science in Europe through C.E.R.N. and similar bodies and a constant interchange with people coming and going. With the Sorret Academy there are many reciprocal visits, organized by the Royal Society and quite a number of people working in laboratories. We are very good friends with them; we go quite often and see or work in their laboratories. There have also been a number of missions concerned with the industrial angle—the Minister of Technology, Mr. Wedgewood Benn has gone on one recently—and there have been quite elaborate agreements for exchange of information. This agreement has been published. What they actually amount to I do not quite know.

I think in all such cases you can go a long way but when you get to the border of commercialization, then you get problems. The British government cannot go to the U.S.S.R. and say that it wants to collaborate, say, to manufacture diesel engines because in the United Kingdom it is the firms which manufacture diesel engines, not the Government. So, to some extent these agreements are rather general. On the other hand, they can open up the possibility of really big commercial deals, such as the Russians have made with Fiat in Italy; also a lot of heavy chemical engineering contracts have been won by England. These goodwill missions by the ministries or the academies can establish relations which may lead to commercial contracts, but they cannot themselves make commercial contracts because in the U.K. they do not manufacture. That is the key point.

Senator Cameron: You were speaking of the computer industry I would say that probably it is fortunate for the U.K. that there is an Iron Curtain, because on visiting factories in Poland and Czechoslovakia last year and looking at the computers, I found they were nearly all U.K. equipment. I asked whether they had any U.S. equipment and they said, "No, it is not government policy to bring them in."

Professor Blackett: I think that is being exploited very well. We have sold quite a number.

Senator Grosart: Do you have any state-to-state selling as you had in wartime? Is that continuing?

Professor Blackett: I am trying to think of any case. I have no doubt that some government departments buy in from another state, but I am not sure about it. I would have thought one could expect that in the defence field, but I have no detailed knowledge.

Senator Grosart: You have spoken a good deal about rationalization of the national effort at the management level. Would you care to comment on the question some of us seem to have, that Britain has a rather low level of rationalization at the labour level?

Professor Blackett: I cannot say really very much on that. It seems to me not a very up-to-date scheme. On the other hand, we lose by strikes a great deal less man hours per year than France or America. We have not got a bad record in strikes. I have even heard economists say that we have got too few strikes, because there is then not enough pressure from the trade unions on the managements to improve their productivity. I do not know whether our union system is out of date or not. Obviously, it is subject to change. However, we have not got a bad record, actually. However, we have got a rather bad record for low productivity, but it is by no means wholly a union job. It is much more a managerial job.

Senator Grosart: Except that this might very well be related to your low per capita level of strikes?

Professor Blackett: It may be.

The Chairman: You have been talking about the effort of the Ministry of Technology to ensure more research in various individual companies. Are you also trying to encourage the organization of co-operative research on an industry basis?

Professor Blackett: Yes. We have got an old established network of about 42 research associations, which we inherited from over twenty years ago. Some of these are well known like the Shirley Institute which deals with research in textiles. Then there is the British Iron and Steel Research Association —BISRA. Another important one is PERA—Production Engineering Research Association. The research associations are partly financed by the government, but they are mainly financed by industry and they are run by the industry and not by the government, with advisory committees, and so on. Some are very good, and all are useful, but they are not all enormously useful. One of the factors is that the big firms seldom send in their major problems to them, but try to tackle them themselves. Some research associations may become not much more than trouble-shooting organizations, to help the small firms through their difficulties.

The Chairman: Is the Ministry of Technology not trying to put new life into them?

Professor Blackett: Oh, yes. It is very active; and it is very active in the regional offices, in which it tries to upgrade the local industry, by telling them what to do. This is all described in the publication of the Ministry. There is a good deal of literature on it, which I could leave with you or have sent to you with these various things. There is a very big service. I have one book here, Technical Services for Industry, published by the Ministry of Technology, 1968, which I can leave with you now.

There is also a good deal of literature from the Minister in regard to calibration services, metrication and other various things we do for industry.

Senator Grosart: Would you care to comment on the possible significance of the idea of an Atlantic common market, on Britain?

Professor Blackett: It has been discussed a lot but, for good or ill, our government, like the previous government, has put it as its aim to get into Europe and the Common Market. The Atlantic market has been a sort of possible alternative, if we eventually are kept out of the European Common Market. The present government has not admitted that the veto there is permanent and it is still official policy to bide our time, to leave our cards on the table and to be prepared to go in when the situation allows it.

While that is the policy, no detailed consideration of the wider resort would be considered. However, I am not up in Common Market politics, which is quite complicated.

Senator Carter: I was going to follow up the question from Senator Grosart earlier. In reply to Senator Grosart, I think you said that the low productivity was not particularly related to labour but could be related to some extent to management.

Professor Blackett: Mostly.

Senator Carter: Mostly to management. In the case of American subsidiaries, do they have American management, or do they have local management; and if they have American management, is there any noticeable difference in productivity?

Professor Blackett: Some of them do have American management and some of them do achieve something like American productivity. But there are cases reported where factories have been built in the U.K. the split image of ones in America and with everything the same, yet the productivity has been considerably lower.

Senator Grosart: Have strikes been high?

Professor Blackett: It is hard to say. It is not the tea breaks! A lot of work has been done on the question of productivity, but it is still very obscure why we are so much lower than America.

I think people talk about people in the U.S. being more dynamic. The hours of work in the U.K. are actually longer than in America, not shorter. It is a fact worked out years ago that the average operative in the United States has about two and a half times more horse power—that is more mechanization—than a man in England. Even so, these are things you cannot change quickly, there is need of capital investment in modern machines, in more rapid handling, in more machinery for moving things about, which is much better mechanized in America and allows shorter hours of labour. If you take as a minimum £ 2,500 a year as the output per head in the U.K., then one might find £ 7,000 a head in America. However, I have known firms in England which hope to achieve £ 7,000.

Senator Carter: We have a productivity gap in Canada with the United States of around 25 to 30 per cent, depending on the industry. Our Economic Council of Canada related that to the difference in education. Is there a similar reason, would you assume that the same would be true in England?

Professor Blackett: Our gap is much bigger than yours, very much bigger. I think education has something to do with it. We have had an extremely good but elite education, traditionally. It seems now that the lack of higher education for a large fraction of our age group beyond 16 years or so, is a hindrance in relation to modern technological industries. It may not have mattered in the old days, but it does now, and the educational gap may be responsible. I do not think I have seen any really serious estimate of how much it is. It may well be part of the reason for our low productivity. On the whole, I consider it mainly a managerial failure.

Senator Prowse: How about the supply of qualified engineers or technical people? Do you find you are limited because of the limitation in the numbers, or are you adequately supplied?

Professor Blackett: We have too few in absolute terms in the country, particularly in industry. We would like more. But it does not mean that there are enough jobs attractive for a lot more at the present moment. Unfortunately, some parts of industry do not present a very good image to all the young men: this is partly responsible for the big brain drain of engineers, which is very much higher, than for scientists. There is certainly a need of more Q.S.E.s—qualified scientists and engineers. But it is not only a question of taking on more to do R. and D.; but taking on more to the other branches of production process, that is to the various centres of the innovation chain. My own hunch would be that nationally we have too big a fraction of Q.S.E.s on the R. and D. aspect and too few on the production and manufacturing end of the chain.

Senator McGrand: I see in your notes that you say they are not paid as well. Relatively how much underpaid are they as against the Canadian or American counterpart?

Professor Blackett: In general the ratio of American to British salaries may be about two and a half to one, or something like that. It is quite big.

Senator McGrand: Across the board?

Professor Blackett: I think in the lower age group the differential is very large, but it is very difficult to translate dollar prices and to make a real test. However, I do not think professors are much less badly paid in England than in America, but the young men certainly are. In our universities the young men start at about £ 1,200 a year and then if successful go up to £ 4,000 to £ 5,000 as a professor. Thus the increase in salary with age may be a factor of four or five in the United Kingdom, whereas in America the increase may be not much more than a factor of two to three. So in the U.S. the academies have big starting salaries but have less rapid increases compared with the United Kingdom. Therefore, there is a tendency in England to have a brain drain, mostly among the young men rather than the older ones.

Senator Prowse: Professor Blackett, does that mean that in England you are gradually producing more technical men than you are able to use?

Professor Blackett: In the sense that they go abroad, yes. As to our ability to employ them, it is a fact that the industry fails to attract masses of them.

Senator Prowse: In other words, there is not the employment opportunity for them?

Professor Blackett: Not at attractive terms. I recently discovered a very interesting fact which hardly anybody seems to have noticed, and that is that salaries in firms of all management—technical, accountant, production, sales, etc.—increases very markedly with the size of the firm. So that a firm of under £ 1 million turnover, with, for example, fewer than 500 employees, would pay all these grades an average of £ 2,000 a year, whereas the corresponding firm with over £ 20 million turnover a year—and so, over 10,000 employees—would pay double that, or in other words £ 4,000 a year.

These facts provide another argument in favour of big firms, or rather another argument not in favour of small firms.

Senator Cameron: Professor Blackett, earlier in your remarks you said that the Ministry of Technology employed 9,000 qualified scientists and engineers on research and development, and 40,000 bodies. Does the 40,000 include the 9,000 which would give you a ratio of four technicians to one scientist?

Professor Blackett: Yes. The 40,000 includes the 9,000. But actually it is more complicated than that, for their is the industrial and production side of the A.E.A. Therefore, many of the 40,000 are not workers on research and development but on engineering design and production of prototypes, etc. So the engineering division is very big, just as in any other factory, and a large number of the 40,000 are to be found there.

Senator Cameron: What percentage of the total scientific establishment would this 9,000 be? Or have you got that figure?

Professor Blackett: Yes. The other day the Permanent Secretary of the Ministry of Technology published the figure that he controls in his stations 9,000 Q.S.E.s on research and development out of a total stock in the country of 55,000 on R. and D. Compared with the 55,000 on R. and D., the total stock of Q.S.E.s in the country, as a whole, is over two hundred thousand. Of course, a very large number of those are in all branches of education and many of them are in other branches of industry than R. and D.

To reiterate, there are 9,000 Q.S.E.s engaged in R. and D. under the control of the Ministry of Technology, including those in the Atomic Energy Authority, and this amounts to 16 per cent of the total nationwide stock of 55,000 Q.S.E.s engaged in R. and D.

The Chairman: I know that Professor Blackett has a luncheon engagement. Thus we might as well adjourn at this moment. Before doing so, however, on behalf of the committee, sir, I want to thank you again for having made this special trip to visit us and to illuminate us. I am sure that we have all learned a great deal this morning from your tremendous experience. Thank you very much, and we wish you a happy trip back to your country.

Professor Blackett: Thank you very much.

The Chairman: The committee is adjourned, then, until 2.30 tomorrow afternoon at which time we shall hear from Professor Porter.

The committee adjourned.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Wednesday, March 20, 1968.

The Special Committee on Science Policy met this day at 2.30 p.m.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: Honourable senators, yesterday reference was made to the brain drain from the United Kingdom. Today we have a very good illustration of that brain drain, but in this case, fortunately, the phenomenon has worked to the advantage of Canada.

Professor Arthur Porter was born in England and graduated in physics from the University of Manchester. He first came to Canada in September of 1949. He returned to London as Professor of Electrical Engineering in 1955, and he came back to Canada in 1958. He is now the head of the Department of Industrial Engineering, and Acting Director of the Centre for Culture and Technology, University of Toronto. This centre was previously headed by Marshall McLuhan, who has moved to the United States, which illustrates another deplorable aspects of the brain drain.

Professor Porter will open with some initial remarks, as is usual, and then we will proceed to the question period.

Professor Arthur Porter, Head of Department of Industrial Engineering, Acting Director, Centre for Culture and Technology, University of Toronto: Thank you, Mr. Chairman. Honorable senators, first, may I say how extremely privileged I am to have been invited to meet with this committee. It may well be, if I may say so with respect, that a new epoch in Canadian scientific research and development has been started with your deliberations, because I believe, and here I will use a phrase of McLuhan's, that you are anti-environmental in your approach, and that means imaginative.

My presentation will be given under five heads: goals; present policy; related questions; some tentative proposals; and what I regard as some of the key areas. The first part will be rather philosophically oriented.

The main question facing us and indeed facing society in general is, a feel, how and in what directions do we want the world to change? "Change" in this sense refers to the physical world, and this is largely in the hands, of course, of scientists and technologists. So very frequently when we talk about science these days what we are in fact talking about is technology. Most of the space program is a technological program and not a scientific program.

I believe that of themselves political, cultural, social and economic events do not bring about the physical changes I am talking about, although they are central in the creation of the appropriate climate and the appropriate environment. One of the points I shall stress, because I regard it as a major issue, is that a national scientific policy must be predicated on fruitful interaction not only between scientists and technologists but also between scientists, technologists, humanists and social scientists. Indeed we are facing now the problem of bridging the two cultures of Lord Snow. I believe we have made a start, but much still remains to be done in this direction.

The question I pose—How do we want the world to change?—is clearly one involving social values and political decisions; and since science and technology, by their very nature, are so very important in being the mechanism whereby change is carried out, then we have to study their effects in order to come to viable decisions relating to our social goals, for instance.

Today, in a real sense, governmental science policy is synonymous with national science policy, because governments are becoming increasingly responsible for the financing of scientific research and development. National science policy must be formulated, I believe, from two points of view: first, a policy for science; and second, how the policy-makers can come into a viable partnership with science. So, these are the two aspects. All I am really saying is that there must be an increasing synthesis of scientific knowledge, on the one hand, and social wisdom, on the other.

I believe the need for "interpreters of science,"—who will probably have been trained in the scientific idiom, because this is the only way they can interpret science in an objective way—is becoming increasingly urgent, because the more specialized science becomes, the more specialized technology, by definition the more specialized the languages involved and, therefore, the more difficult to communicate, even between individual branches of science, let alone between branches of sciences and the social sciences, for instance. I am certain that something can be done about it. Expo 67 was a demonstration of what was done about it at Montreal, because in a real sense this was part of the objective of Expo 67 whose theme "Man and His World," lent itself so admirably to communicating the world of the scientist and technologist to the layman and student.

What we must try to do—and I am still dwelling on the background philosophy—is to optimize rare resources, and that means rare resources, especially people, not only in science and technology but in science, technology and certainly the social sciences and increasingly the humanities. It is a question of optimizing these resources not merely from the point of view of single individuals, but more important from the point of view of groups of individuals and the interaction between these groups.

The next step, of course, is how these groups will interact with the environment. The danger is that we always tend to formulate our national scientific policies on the basis of old environments. It has happened so often throughout history, as pointed out by Marshall McLuhan, that man fits his latest technology and his latest ideas into an old picture. The "horseless" carriage exemplified this fact. This characteristic of man has been called "rear-view mirror driving"—driving from the past, fitting new technologies into old environments. An important point that might be stressed in this connection is that if we formulate our national science policy without taking into account the tremendous advance, for instance, in communications and transportation, we might well get on the wrong track and be operating in the wrong environment.

What I mean is this. In the scientific field, particularly today, it is far easier to transport people to facilities, especially if the facilities cost millions and millions of dollars, then perhaps it is to create the facilities in one's own backyard. Again, with satellite communications, which will be considerably expedited and evolve in the future, one has the concept of the "global village" in a very real sense where communication between interested groups of people anywhere on earth will be possible, and this is particularly important in science and technology because there is a high degree of commonness in the language, even though the natural languages may be quite different.

Perhaps it is presumptive of me to start by not so much criticizing but commenting on present government science policy, as I see it. I shall make four or five points which will lead later to some fundamental questions.

Government financing of scientific research and development—and by this I mean the whole spectrum, from basic research right through to the creation of pilot facilities in industry—appears to be inadequate. And, as I am sure you, sir, and the committee have heard on other occasions—indeed, it is catalogued in the Royal Commission Report on Government Organization—we are behind other industrial nations in expenditures in this area.

Senator MacKenzie: Could I ask one question on that, because it has been pointed out on a number of occasions. Does this include defence expenditures?

Professor Porter: Yes, taken by and large it does.

Senator MacKenzie: The fact that our defence expenditure is much lower than that of the United States—

Professor Porter: It has a very important effect.

Senator MacKenzie: —it does not really give a true picture of the situation?

Professor Porter: This has a very important influence, because so much of the scientific research expenditure of the United States comes under the umbralla of defence, though much of the research is not defence-oriented.

Senator MacKenzie: I know that.

Professor Porter: For instance, in the case of the United States Air Force, some of the research programs are at very basic levels—it is pure research in the real sense.

Senator MacKenzie: And the same is true, to a lesser degree, of the United Kingdom?

Professor Porter: That is quite true.

Senator MacKenzie: I am sorry to interrupt, but I wanted it on the record.

Professor Porter: I mention a related point because I believe that in the immediate future, and perhaps during the next five years, there may well be a "reverse brain-drain" vis-à-vis Canada and the United States. Already in the universities we sense this, because we are getting many more applications for posts in the universities and for research activities than before; and, as we all know, there are all sorts of reasons for this, but it is a very interesting factor.

The second point is that with present budget levels, I believe there is an almost unhealthy balance, or imbalance, between research expenditures in government laboratories, as compared with research expenditures in the universities and industry. This is quite marked.

The support of R and D, for instance, in industry poses some difficult problems. When it is recalled that a single scientist or engineer in industry, with supporting staff, may cost a company at least $60,000 one begins to see that to build R and D capabilities in any but the largest industries is not very realistic, because, again, an R and D team must be of a certain size. You cannot have an R and D team of one professional. It depends, of course, on what area you are talking about, but a minimum of five to ten would be about right.

In the United States, I believe—and Senator MacKenzie brought up this point—if defence spending is taken into account, the total government allocation of R and D funds to industry constitutes about 60 per cent of the total. It is of this magnitude, and this, as I say, is about ten times what, on either a G.N.P. basis or a per capita basis, we in Canada spend.

There is a related point, that science and technology by their very nature are regenerative processes, once you get them going. You build up hopefully from a good base—you cannot obtain this regenerative process, or an effective regenerative process, unless you have "critical mass". You must start from a size that is capable of taking off, and this is a very, very important point. I believe that unless one does this—unless one achieves critical mass—then, in certain areas that I shall discuss later, the nation's confidence in its scientists and technologists is bound to be undermined. We are overly fragmented in too many of these areas, and not many of them have achieved critical mass.

I might mention some examples. I am sure there are many more, but I know of two. One is very well known to you. It was the Arrow project which was not followed through. The other was a project that perhaps you have not heard of. It was a project called Datar, which at the time, about 15 years ago, was a defence-oriented project in which Canada made a tremendous breakthrough in information technology, about which I shall say more later. I believe Canada was the first nation to set up three individual data-handling systems and to tie them together over radio links. This was carried out by a team of about 30 young Canadian engineers, many of them engineering physicists from the University of Toronto, the University of British Columbia, the University of Alberta, and indeed from across the country.

I mention this in view of Professor Blackett's remarks yesterday when he talked about the computer industry in Britain, and mentioned, in particular, the I.C.T. company and how they have some 30 per cent of the British business in this field. As I mentioned to him after the hearing, and with which he completely agreed, the basic development of the I.C.T. computer series was carried out in Canada. This was a development of the selfsame 30 or 35 bright young men who developed the computer called the FP-6000. Subsequently the I.C.T. obtained sufficient U.K. funds to support further development and today the system constitutes an important part of the domestic computer business in England.

This is a case where perhaps only $2 million at the time 1954-55—I was heading the Canadian group so I know at first-hand what was involved—would have made a profound impact in this whole field, because we were ahead. We were not only ahead in interactive computer systems, but we were ahead in modular solid state computer technology, which is the basis of the modern computer.

The third point—and perhaps I have dwelt rather too long on the second—is the fragmentation of effort that we see in many fields of science and technology. Associated with this we find perhaps minimal interaction between these groups—between Canadian scientists in government service, universities, and industry—because there are so many groups. If you have a large number of groups, interaction and dialogue between them is obviously made that much more difficult.

I believe—and this is my fourth point—that the formulation of science policy and its implementation at the present time appears to be what I would call overly environmental. I apologize, sir, if I am rather too McLuhan-ish in my idiom. What I mean in this respect is that it is too predictable. This is a fruit, of course, of the scientific establishment—and there is of course a scientific establishment in all countries.

Perhaps one reason for this—although I do not think it is by any means the main reason, but it is symptomatic of what I am talking about—is the fact that the constitution of the Science Council is very science- and engineering-oriented, while the constitution of the Canada Council is more interdisciplinary. Perhaps if one had the opportunity of bringing social scientists and the humanities into the deliberations of the Science Council you would get some of this imaginative and rather different sort of thing.

It happened at Expo where I was privileged to chair the Advisory Committee for Science and Medicine. Without the social sciences and the representatives of the humanities on this committee and its subcommittees we would have been much too environmental. We would have put science and technology to the forefront without, perhaps, due regard for the arts, and we would have missed a very great deal, and the whole exhibition would have suffered.

In fact—if I might say a word or two on this, because I think it is relevant—here was a situation in which science and technology were central, and yet in spite of the fact that the general public is very suspicious of scientists—it regards black boxes in the way of mythology and mysticism—they loved it. They were involved. This atmosphere was created, as I say, but the interdisciplinary effort, and not only by scientists, doctors or engineers. It needed more than that.

This brings me to the question of interdisciplinary research. I would say that we do not have enough of it, not enough in Canada nor enough on earth. There is certainly not enough in the United Kingdom, and I do not think there is much of it in the United States. Interdisciplinary researches that relate the humanities, the social sciences, and the exact sciences, I would suggest, are of profound significance to society at this stage. Perhaps one reason why there has not been much emphasis in interdiscipliway research is that the scientific literacy, even of the educated layman, is not particularly high. Perhaps a national science policy must take this into account too. How can this be done painlessly?

May I now introduce some basic questions which I feel are relevant to science policy. First, in view of the central role of government in financing scientific research in its own establishments, in industry and in the universities the question is: how can a more dynamic attitude be achieved? How can we seek out excellence? Yesterday one, or perhaps two, honourable senators raised this very question in the discussion with Professor Blackett.

Having research grant applications coming in to some central organization is, of course, important and obviously must continue, but going out and seeking centres or areas of excellence is also very important. I know of several such centres which in the normal course of events will probably be ignored because people do not hear of them. For example, probably very few people have heard of the so-called Datar project which I mentioned previously.

The second question I raise is: how can scientific and technological resources, especially those of trained people—and when I talk of resources I mean about 95 per cent people and five per cent the sort of equipment they use—be redeployed, and how can a more equitable balance of research funding between the major centres be achieved?

Then I ask: How can we achieve greater mobility of scientists, perhaps between the universities, government and industry? This, I believe, is a very important point.

Having sorted out these areas of excellence, how can we establish centres of excellence in such fields as communications and computer science, water pollution, nuclear science, upper atmospheric research and so on?

My fifth question, to which I think I have referred at least three times before, is: how can government science policy capitalize on the techniques utilized in the creation of the learning environments of Expo? There was there a melding of two very important factors. On the one hand there was rigorous planning, without which the exhibition would not have opened on time, and on the other hand high-level creativity.

My last question refers to the educational implications and again reiterates a point I made previously. How can the nation be made more scientifically and technologically literate?

I have some proposals which are extremely tentative, very much off the cuff. My first is that I believe perhaps this committee should consider the appointment of a full-time scientific advisor to the Prime Minister. This would recognize that we as a nation believe that the field of science and technology has a vitally important part to play and is, even on a day to day basis, affecting our environments and, more important, affecting our international relationships. This sort of appointment, of course, would parallel appointments in the United States.

For instance, an old friend, Dr. Jerome Wiesner, was scientific advisor to the late President John F. Kennedy. He was in almost daily touch with him; not for long, maybe five minutes or so. Certainly when key problem areas arose Wiesner could bring in the top talent in the U.S.A., wherever they were. He had his panels or committees of experts and could get them to Washington within 36 hours.

I think that the Science Council of Canada, in spite of the fact that it has not been running very long, in spite of the fact that I am a tremendous admirer of most of its members, particularly the chairman, Dr. Solandt, apart from perhaps bringing in a more interdisciplinary flavour, is not adequately dynamic and it is a little too large, with perhaps too much official representation. Maybe one or two senators and/or M.P.s might be on a committee of about 12, which perhaps should be the total membership. In addition to the senior advisory committee, however, we would have advisory committees for special areas, similar to those in the United States.

This, of course, would do a great deal to enhance the prestige of Canadian scientists —they would feel that they are part of the decision-making process.

I would suggest that in the scientific advisor's office there would be, in addition to facilities for the general running of the advisory groups, two areas under two directors. I would call one the Director for the Advancement of the Arts, Sciences and Industry. The other would be the Director for the Assessment of Scientific and Technological Research. The first would be responsible for the seeking out, even at the most humble levels, of areas of scientific excellence—bright young people. That is really what I am saying. The second would be concerned with the assessment, from the point of view of scientific merit, technological implications and sociological implications, of massive projects which may cost in the order of several millions of dollars.

I also advocate the setting up of something like federally supported National Symposia in the fields of the exact sciences, social sciences and technology. This sort of thing exists nowhere, as far as I know.

The British Association in the United Kingdom comes close to it. The idea would be that the Symposia would provide for the initial screening of papers, involving new ideas and new concepts, new technologies and so on. This would give the scientific community, by and large—and they are the most critical community on earth—the opportunity to carry out the first screening. This would mean that the job of being director for the assessment of these projects, would be made very much more simple.

I come now to the areas of major significance, which is my next topic. I would suggest that the criteria for the selection of research—and I include in "research" the area of technology and development—are as follows. The first question is the question of the balancing of cost against the potential value of the research. In spite of the fact Professor Blackett has stated that it is not possible to measure scientific research *per se*, objectively I believe we have to find some means of doing it, because when one extrapolates research expenditures going on all over the world, surely we must find some basic criteria on which decision makers can base decisions.

Admittedly, one constraint Professor Blackett put into the system was that basic scientific research should not exceed about .3 per cent of the GNP. But if you can imagine some 50 projects say, all operating below "critical mass", the country would not get good value for the .3 per cent of the GNP expended.

We must devise some criteria of excellence, even in basic research. I am not at this stage talking about technology or development, because these are much more simple to cope with. The only real measure of excellence in basic research is, of course recognition by the international scientific community—which means publications in international journals. How often are the publications referred to by recognized scientists? This gives, in my view, a reasonable measure as to how one is stacking up internationally, and this is vital in basic research; basic research is international, it is not national, in any sense.

The three criteria of merit I suggest are,

(i) The potential role of the research in the future evolution of education, science and technology.

(ii) The potential value of the research to Canadian society (value judgments are innate in such assessment).

(iii) The potential value of the research to the Canadian economy.

(iv) The achievement of a balanced program in which the support of pure research, applied research, and development (i.e. technology) is assured at adequate levels in each sector.

The assessment of what these levels should be will in itself constitute a major question and one upon which perhaps the advisory councils would be able to advise.

In such fields, for instance, as high energy physics, and cosmology, which may involve large capital expenditures of hundreds of millions of dollars—we will see more of these in the future—I would contend that the time is coming, perhaps within the next ten years, when international co-operation in the real sense is likely to be the only means of producing the results which society as a whole wants. This is tremendously important. Unless we get these results, unless we continue these probes of the natural environment, and even far beyond the natural environment, the interior of stars, and so on, then we will not be in a position to keep our society going in the real evolutionary sense.

Even the giants, the United States and the U.S.S.R., in many of these fields will find that the cost is beyond their internal budgets. With the proliferation of jet transportation, with the importance of communication, satellite communication and so on, very clearly the climate will soon be ripe for international discussions in these high-cost areas. This is a very important point referred to also by Professor Blackett.

I shall now introduce the major topic of this submission. It concerns the basic areas of research in which I believe the Canadian Government should be investing heavily.

Of the highest priority is the field of information science and technology—the "central nervous system" of society. Nations with the most highly developed central nervous systems will be in an extremely strong position —just as man's ancestors a million years ago had the most highly developed nervous systems and subsequently became the dominant species—so with society.

The problem area, when one talks about information science and technology, covers computer science, computer technology, and the whole field of communication networks—a field which has been described as cybernetics, a field which affects the whole of society and will do so increasingly in the future, both government and industry, the academic world, and so on. During World War II Professor Blackett started—and I was very fortunate to be a member of his team—the idea of operations research and systems analysis. This is now permeating the whole field of business in the United States and, increasingly, Canada, although, strangely enough, at a lower level in the United Kingdom. This is a field of systems study in which computers, for instance, and communications networks are absolutely central.

The extent to which the Soviet Union, for example, has recognized the profound significance of this area is exemplified by some extracts I have taken from a recent article by Dr. Glushkov, Vice-President, Academy of Sciences, Ukrainian S.S.R. and a world authority in the field of cybernetics. Dr. Glushkov, talking about the year 2000—and I believe we should be thinking about the year 2000 rather than the year 1960—has this to say:

> First of all, the hardware basis of cybernetics—the computer—will change significantly...

It will be possible to address machines in ordinary human language. Not excluded is that by this time (the end of the present century) electronic devices will be helping to develop a single human and machine language, more perfect than Esperanto...

A single communication system will include an enormous pool of computers and will become a single system for storing, processing, and transmitting information...

The existence of such a system will radically after the work of scientists and designers.

... Most important, the system will accumulate different methods for obtaining new scientific results.

I quote from this article to demonstrate that not only is the computer used in the more mundane activities of business and government, the clerical operations and so on, but it will be at the very core of scientific research in the future. It will support not only scientific research but also research in the humanities and the social sciences. And, most important of all, we have a concept and hardware which will bring about the interaction of the social scientists with the scientists, the engineers, the humanists. It is already doing so. We have in hand one of man's greatest inventions which is only in its infancy. Its capabilities in the field of information retrieval and information patterning are fantastic.

Today I had lunch with Mr. Yoemans of the Treasury Board. He was discussing, for example, the implications of this sort of technology for the Department of External Affairs, in the handling of the vast amounts of information coming in each day and in developing some patterns in this sort of information. The Treasury Board, also, has a new concept of programmed budgeting, the whole of which is central to its activity as it is in many businesses today. This is in no way going to do people out of jobs. It is going to relieve humans from clerical slavery, just as the bulldozer has relieved them of manual slavery and is increasingly doing so.

I have introduced this subject specifically because Canada's contributions in this field have been quite spectacular. We have in this country today groups of bright young men whose thoughts and ideas and expertise in the field are second to none.

Canada produced the first computer traffic control system on earth. But unfortunately it has not been followed through. We might develop tremendous export of these systems, and the artifacts associated with them because here is a means of saving life, of improving transportation in a real way, of changing perhaps even the economies of some countries. Spending money on computers rather than on roads may be very desirable. I believe it is of tremendous significance. We have also a first class group of people working in the fields of airline reservation techniques, digital data communications and the necessary "software".

I would not at this stage advocate setting up a computer industry in Canada, but within 10 years the hardware may only constitute 30 per cent of the total cost of systems. The key question is how you use such systems, what communications, what peripheral equipment will be associated with them; these are the things that are going to count. In other words, what will be important will be the top people using the equipment, not the equipment itself. And in this field we have considerable potential.

There are four other areas that I have listed at, I would say, lower priority, although, of course, they are of tremendous importance. They are energy generation and distribution; water and land conservation; urban planning; and air and water pollution. These fields will be a must in the future. Clearly, there are other areas as well, but I thought, sir, that I would mention the above areas specifically. Thank you.

Senator Norman A. MacKenzie (*Acting Chairman*) in the Chair.

The Acting Chairman: Thank you very much, Professor Porter. I suggest, ladies and gentlemen, if it is convenient to everyone, that we take a short recess.

(*Short recess*)

—Upon resuming:

The Acting Chairman: I have known Dr. Porter for quite a long time; he nearly became one of my colleagues at the University of British Columbia some 15 years or more ago, and it was a matter of regret to me, and I hope it was a matter of regret to him, that this just did not happen. However, partly because of that, I have been interested in his career ever since. I was delighted to learn he was to be one of our witnesses and would appear before us to give us some of his views and some of his thoughts on this very important subject that we are studying and discussing. Perhaps it would be in order if I make a brief statement and then we can proceed from there. I just want to say, without making a speech, that I am not a scientist myself, and I cannot, unfortunately, claim to belong to the new generation that is doing so many exciting things in the fields of science. However, I would like to put to our guest and to the members of the committee one point of view that is constantly with me, as one who has a special interest in the social sciences and what I claim to be the oldest of all social sciences, the law and the humanities. Granted all that science has done, is doing and the limitless future that it promises, the facts remain there are more human beings in the world today than we have food for, and there seems to be more violence in the world today than ever before in history and less disposition on the part of human beings to be reasonable about their problems and programs. My concern is whether or not we human beings can with the various techniques available and with such limited knowledge and wisdom as we have of human nature and human beings do anything of a constructive nature about what I consider to be the major problem of modern society. Now, with that little comment in the background, Senator Hays, I gather you would like to ask a question.

Senator Hays: First of all I would like to thank Professor Porter for being here. Yesterday and today have been for me really stimulating days. Of course I am just a farmer and I don't know too much about the sciences and as I was just telling Senator Kinnear a moment ago I would like to have been born in another environment perhaps closer to Senator MacKenzie and I might have known a little more about these things. However, I would like to ask Professor Porter if in his opinion, since it seems that we do not have the resources to do all the things we would like to do in the field of sciences—I would like to know if in his opinion we need to spend the money we have in a different manner. I think this is one of the purposes of the committee to examine into this and to see if we are falling down in Canada. Our problems are somewhat different to those in other countries; we have a great country with few people and some of our great problems are going to be in the fields of transportation and expansion. We are not going to be holding back; we are going to be increasing in all fields. We have great natural resources. So where could we better spend our time and talents in so far as applied research and that sort of thing are concerned in your opinion, Professor Porter?

Professor Porter: This of course is the central question. I believe that at the present time we have got an overly fragmented research and development program. In other words, as any vibrant nation, we try to take on everything and perhaps we try to compete in everything with the giants, and of course this is completely impossible. In fact the giants themselves cannot compete any more. So it seems to me that a very searching assessment of the requirements is necessary and certainly very high on the priority list we must put transportation, agriculture, pulp and paper, and water resources since this nation is so vitally dependent upon these things. There are all sorts of reasons for this. Geographically we have got to have a very flexible and sophisticated transportation system and with that we have got to have a communications system. And I stress very much the great importance of communications. Perhaps I would not say it is more important than transportation, but transportation, pulp and paper, water resources, and agriculture are, in a way, rather inward looking whereas I was thinking of looking outward to see where Canada might make a tremendous contribution in the sciences and technologies on a world basis.

But my answer to your question is that I believe there is much too much fragmentation of effort and this, in a sense, is due to our geography. I mean it is not easy to transport a man, or it wasn't 20 years ago, 2,500 miles and to have him set up his home in an area where some research and development is going on in which he is very competent. Perhaps he would like to set it up himself. But this has happened over and over again, and I don't think we can afford it. We simply have to take a real look out, get these things together and achieve more unification.

Senator Carter: Following on that, you mentioned water resources in reply to Senator Hays. Are you including in that the oceans? Because Canada is a maritime country and I have a feeling that we should do the things that come naturally to us. For example, we have a fishing industry in which we should be experts. In all phases of oceanography and the fishing industry we should be pioneers and yet we are letting the Japanese do it instead. Again, I noticed you did not mention the Arctic. Surely we should be experts in the Arctic since next to the Russians we have important interests in that area. Do you have any comment on that?

Professor Porter: Yes, I do. It was very remiss of me not to mention oceanography and the Arctic. In my manuscript, as a matter of fact, both these areas are included. Oceanography and the northern environment are obviously of great significance. Even taking the northern environment from a communications point of view and the fact that it includes the North Pole means that it lends itself to research into the magnetic properties of the earth which in turn will have a profound influence on communications. But, of course, there is much more to it than that. It has been said that Canada and the U.S.S.R. in certain areas of the north might well have co-operative international research stations, and with this I would very strongly concur. As far as oceanography and the fishing industry are concerned, they are basic; and, at all costs we cannot ignore our basic industries, in spite of the fact that from a glamour point of view some of the other fields look rather more attractive. I would agree with you wholeheartedly.

Senator Carter: You said that we were fragmented and we could very well dissipate a whole lot of money into a number of programs which would not achieve anything because they were below the critical mass. How do you find out, how do you know whether you have a critical mass or not?

Professor Porter: In the basic sciences and, indeed, in the applied sciences—and I include Medicine as an applied science in this field, as well as engineering and, perhaps, architecture—the criterion is international acceptability. A research unit that is really contributing is very quickly the focus of attention of scientists on a world basis, and I would say this is the only criterion.

Now, when we discuss the criteria for development in industry, say, this is more difficult. I suppose that eventually it is the balance sheet, but there is quite a time-lag and, therefore, what one has to do is to pick good people. This is not too difficult in the sciences and technology. I found, when I first came to Canada—and, as a matter of fact, I first came in 1949—I was involved in industry for six years—that there was not much difficulty in spotting the spark in a man's eye. And then it was a question of giving him enough latitude to go ahead. So, I think this is the sort of criterion. Everything we have been talking about involved people. When we talk about science policy, we are talking about people, and how best they can be utilized and put in the right sort of environment so that they are going to create.

Senator Carter: If I understood you correctly, you mentioned something to the effect that Canada did some pioneering in molecular solid state computer technology. Where do we fit now? What is our position now compared to other industrial countries with respect to computer technology?

Professor Porter: I would say it is not too high at the periphery, because events have taken over. Massive corporations, particularly in the United States, have been proliferating. Indeed, one large computer company has a $125 million a year research budget. That sort of budget means, just in itself, that they have tremendous resources and they can attract a lot of Canadians to join the enterprise; and this has happened, of course.

On the other hand, in certain areas we do still have "know-how", ability and creativity; and these are the areas that are not often thought of in terms of the computer as such. They are the areas concerned with providing information for computers. The first Air Canada Reservation System, for example, when it was first installed—and it could have been installed four years sooner than it was —was ahead of the field at that time. Canada had the first computer sorting letters and the associated technology at a time when no one else on earth had; in fact, the Americans were coming up to see it.

What I am really saying is that in the special purpose areas—like this reservation system, like the letter sorting, like the control of traffic in cities—this could be a billion dollar industry—we have great potential. But others are catching up on us. The Toronto traffic control is operating at only about one-quarter of its potential. They need about another million dollars to really put this system right on the line. Where do the funds come from in operations of this sort? Once you can get a viable road traffic control for cities of, say, half a million people and up, going, then turn to the world market; it is just fantastic—and this is what I mean. We are certainly not in the league of the large-scale computer manufacturers, but we still have great expertise in the utilization of computer systems, and in the production of languages for them. I noted this when I first came to Canada.

Let me give you just one example—a development Professor Blackett mentioned yesterday concerning the I.C.T. organization in Britain. The computer which I.C.T. took over in its entirety was designed by ten young Canadians—when I say "it was designed" I mean "it was conceived and designed". It was taken through all the stages of the logical design. It was designed using new electronic circuits. And then the computer languages, and what is called the software, and so on, was developed. And this was the first system on earth with the capability of time-sharing, since that time the universities of M.I.T., Stanford, and California, have expended great effort in the field. This group of about twelve engineers achieved all this—it was a bit like Expo. You take on an operation that is virtually impossible, and by some means or other it is done.

These men are still in Canada. They are in fragmented groups at present in small companies which are struggling to compete with the giants, but the fact that a small company of say, eight people can compete with giants means it has got something. That is why I say, be outward looking: "Find those areas of excellence," meaning people of excellence, "and then see what we can do about it."

Senator Hays: I should like to follow up one question on transportation, which I am sure is in your field as well. This is one of the great problems. It seems to me that it is the greatest problem. Senator MacKenzie mentioned food and hungry people, but you can grow the food, but if you cannot get it to the people you cannot solve the problem.

There is the problem of people having to spend hours going back and forth before they can reach the computer to make it work. Is there not a field in which we could have a group of people who would really do some work on this. There is no place on earth that I know of—and I have been in about 40 different countries—where transportation, both rural and urban, and so on, is not one of the great problems. It seems to me that with the number of people we have we are not getting to these places as fast as we were getting to them many years ago, because we are taking up more room, and that sort of thing.

Professor Porter: That is quite true. Interestingly enough, many studies have been carried out already, but the continuing studies in this field of transportation are in the selfsame field of information science. You have got to have the model before you can begin to assess the economic viability of a system. In other words, more and more one must be pretty sure before starting a mammoth manufacturing and building program, especially in transportation where one is involved obviously with billions of dollars for the aircraft industry, railroads, and so on. So, the selfsame systems techniques can be used. The most important problem in transportation today is in being able to operate at these levels, and Canadian National Railways now has one of the strongest teams in Canada in operations research. I think we are seeing the effects of it all along the line. Dr. Solandt started this, and it should be extended. I am sure the Transportation Commission in Ottawa—in fact, I know—is very conscious of this sort of activity.

You have to decide whether you are going to have ultra high speed 150 miles an hour intercity railroad traffic between cities 200 miles apart, and whether you are going to extend it from Toronto to, say, Winnipeg on a similar basis, or whether you are going in for transportation from airports to the centers of cities. Are you going to optimize your airports? Are you going to look into the whole problem of moving wheat and grain through pipe lines. These are all parts of the transportation problem. Are you going to look into Churchill as a major port in this self-same transportation network?

What I am really saying is that you cannot go at it in a piecemeal way. You have got to have the broad concept, and when you have this then you can begin to move in.

Perhaps, sir, I can mention just one significant point here, and it relates to atomic energy. You will know that Britain is not selling many reactors in the export market probably because they were the first in the field. They were building nuclear power stations while the Americans bided their time and carried out extensive studies of such systems. Then, they came in at the stage when what was required was smaller capital cost stations but with higher operating costs—it took a long time to establish this pattern. What I am saying is this: Let us not jump right in and say we are going for say highspeed railroads, and so on, until we have studied the system as a whole.

Senator Grosart: First of all, Professor Porter, I have a note here that suggests that I ask you for the citation of the article by Dr. Glushkov, Vice President of the Academy of Sciences of the Ukrainian S.S.R.

Professor Porter: This, as a matter of fact, was extracted from *Pravda* about two months ago. I have a copy of it at the university, although I do not have one with me. I cited just this small extract, but I can arrange for a copy of it to be sent to you.

Senator Grosart: I have a quotation here from that article, or perhaps from another one by him, and it is as follows:

> First of all, the hardware basis of cybernetics—the computer—will change significantly...It will be possible to address machines in ordinary human language. Not excluded is that by this time (the end of the present century) electronic devices will be helping to develop a single human and machine language...

Professor Porter: That is right.

Senator Grosart: And he adds: "...more perfect than Esperanto..." Would you care to comment on that possibility of universal unilingualism?

Professor Porter: I think what he is meaning here is unilingualism in a very specialized way, because I think one can say, without much fear of contradiction, that unless the great languages of our society are not only retained but developed as dynamic entities society will just wither and die. In other worlds, I personally believe that unilingualism is just not a viable entity for society. One has to have the richness of the different languages, because this is what our culture demands.

I think what Dr. Glushkov is anticipating is an international language in a rather restricted sense, but a very important one. I myself mentioned, six or seven years ago, that one important way in which international stability, if you can call it that, although this is probably overly exaggerated, or international rapport might be facilitated, might be through the establishment, perhaps through UNESCO, of certain centres with computational capabilities around the earth, and capable of receiving information in an agreed language. But, these languages are very, very elementary. They are unambiguous languages. They are at the lowest level of language. They are the languages of mathematics and the languages of logic.

Senator Grosart: These are the highest, or the lowest, languages?

Professor Porter: They are at the lowest level. I would say that the highest level of language is the language of the poet and the artist in which there is condensed into a small compass the whole tremendous range of human perception and wisdom. I was at Mr. Pocock's home last night listening to some Dylan Thomas—this is a very high-level language. However, if you could obtain agreement on these low-level languages among the nations of the earth and if each would send in information concerning problems of basic interest to everybody, for example, disease patterns which are perhaps characteristic of a particular part of the earth, and you begin to sort out this information using computers, the advances in medicine may be just tremendous. This is the whole basis of epidemiology, as the subject is called. You see, even though it is a low-level language, you have induced a little confidence, not much but it is a start, and maybe you can build on it. These languages will soon become a little more sophisticated, perhaps more approaching a natural language, and so they will evolve.

I think this is what Dr. Glushkov implies, that is to get a level of language for communicating with the computers, so that although it is the language of morons it is a start. If this can be achieved, we are talking about a real communication network, a global network in which all nations will participate. This will help solve the poverty problem, and very much help the whole problem of world peace.

Senator Grosart: I do not want to quarrel with your definition of high- and low-level languages, but at one time I spoke some Chinese and I was interested to note that I. A. R. Richards developed basic English with Chinese as a model. A simple language might well be in communication terms a high-level language. In aesthetic terms you have Dylan Thomas or Yeats, but who understands them? I read them both at length, but I will not say at this moment that I understand either of them fully.

Professor Porter: Nor me.

Senator Grosart: It is almost impossible to misunderstand anybody speaking Chinese; it is almost impossible to be ambiguous in Chinese. That is why I do not accept this concept of high and low levels in this field. Shakespeare is very high level but extremely difficult to understand. I should like to ask a clarifying question. I understood you to say that in the United States 60 per cent of the total of government expenditures or funds made available for R and D were channeled into industrial research. Is that correct?

Professor Porter: No. What I meant was that 60 per cent of industrial research funding came from the government.

Senator Grosart: I am sorry, I misunderstood.

Professor Porter: It was probably my mistake. That is what I meant.

Senator Grosart: Then you said that the Canadian equivalent ratio, as I understood it, was about one-sixth of this.

Professor Porter: Of that order, yes.

Senator Grosart: Why?

Professor Porter: That, of course, is a very important question, and I believe this is perhaps the major question your committee will be faced with—why? My own opinion is that the United States is very close to us, and one can very easily take the attitude that if technology is being developed across the border, why should we get involved in it anyhow? I think Senator McCutcheon will be interested in this. I recall once having an argument with the late Colonel Phillips on this self-same question. I did not realize he was my boss at the time as chairman of the board of governors. I said to him after this, not heated but good discussion, that I was sorry to have been so outspoken, but he patted me on the back and said, "This is the sort of thing I like."

This is one factor, and I think it is an important factor—we do receive a great deal of technology, science and development know-how that spills over the border.

The Acting Chairman: The motor car industry would be one illustration of this?

Professor Porter: Yes, very much. This is not going to stop.

The Acting Chairman: You would not want it to.

Professor Porter: No, we would not want it to. It is the last thing we would want, so we accept this. What I feel we should do is to pick certain special areas in which we know we have the top-level people to contribute, and perhaps to lead the world. I have mentioned a few of these areas. Many of them, of course, will be very much Canadian oriented. This must be our very first look-see, to find the areas which our Canadian environment lends itself to. The Arctic is certainly one such area, water resources another, communications, transport, which is rather special. This, I think, would be my answer as to why there has been this large import of technology and maybe not enough confidence has been induced in the minds of legislators concerning Canadian capabilities in this respect.

Senator Grosart: Would you say there is a significant difference between the percentage of government R. and D. funds going into government research bodies, universities and industry in Canada and in the United States?

Professor Porter: Yes, a very considerable difference. Of the funds available in Canada, government laboratories are receiving a very much higher percentage than those in the United Kingdom or in the United States. I am not saying this is in itself bad, because one has to start somewhere. Canada started and built a powerful National Research Council, and built in other areas, but perhaps, as Professor Blackett said, we should begin to look at some programs and say, "Maybe these have run their course and maybe some of these scientists and engineers might be better off in different environments". I am thinking particularly of universities. In agriculture, for instance, there are over 400 Ph.D.s, which is almost the annual output of all Canadian Ph.D.s in the humanities, social sciences and sciences. I wonder whether perhaps some of these people would not be better off training young people in universities, because this is one thing government establishments are not geared to do. To me, this is the most important area of all—the stimulation of bright young people, and this is what we are doing in the universities.

The Acting Chairman: We hope.

Professor Porter: Yes, we hope so, and I think so.

Senator Grosart: You said there were a number of obvious reasons for the reverse trend of the brain drain as between Canada and the United States. Would you care to say what those reasons are?

Professor Porter: I think the first two are fairly obvious—the Vietnam situation and the civil rights problem, in certain areas. I take these as being quite basic. There always will be academics, particularly, who do not fall into the "establishment orientation." But these are not the only reasons. I believe there are more important reasons—the growing excellence in Canada of certain universities, quite a few. I will not name them but they are well known. These are real centres of excellence and we must treasure and support them. This is perhaps a very key area.

The second reason is this. I believe that Canada is the interface between European culture and North American culture—and this is where Quebec is so tremendously important, because bi-culturalism is really keeping this interface in an exciting state—and I mean exciting in a progressive sense. Canada is anti-environmental to the United States—and this is being recognized by scholars and scientists, quite a few of them in the United States—anti-environmental in so far as unexpected and imaginative things can happen here. Because we have one-tenth as many people, our whole economy is much less cumbersome and is quite different—and the fact that we are bi-cultural here. This is an attractive thing.

The Acting Chairman: Could I interject a question that is really, in a sense in the area of ethics? If it is embarrassing, you do not need to answer it. It is a question which has bothered me a little bit.

Your first two groups are coming to Canada, one because of Vietnam and the other because of civil rights. Is this a desirable trait in human beings, more or less to escape from problems; or had they better stay where they are and help solve those problems, unless they are intolerable? I would say that in the case of the Jew in Germany there was probably only one thing to do, if he could do it, and that was to get out before he was interned. But until that situation develops, I feel happier about individuals who do their best to solve the problems they do not like or do not feel happy about.

Senator Grosart: It is a question of which draft you dodge.

The Acting Chairman: Exactly.

Professor Porter: My sympathy is exactly as you say. I do not have any sympathy with these people. I feel one must face up to situations, and that turning one's back on a situation will not solve it. Nevertheless, I feel this is a factor, although I do not know what percentage is involved. The people who apply to me for jobs never mention it, so this is very speculative on my part.

Senator McCutcheon: Is that not the case if you develop a centre of excellence? I can think of one in Toronto with which I am associated, but it is not physically part of the university. It is my experience that if you develop a centre of excellence—a number of top people and a number of related disciplines—as long as you can guarantee to your prospects from some university or centre in the United States the equipment and the funds they need in order to carry on research, they will come up here and work for less money.

You probably go to another place in the United States and work for less money; but you must have a centre that will attract them.

Professor Porter: I would agree, senator.

Senator McCutcheon: No matter if there were two Vietnams.

Professor Porter: I would agree, senator. This of course to the academic is essential.

Senator McCutcheon: That is right.

Senator Grosart: You spoke of the importance of achieving a viable partnership between the policy makers and the scientists. You spoke of a marriage of scientific knowledge and social wisdom, for instance. Would you say that the Ministry of Technology in England has achieved this to some degree greater than we have in Canada with our way of doing it at the moment? I ask that because I was reading this speech of Mr. Wedgewood Benn, and it seemed to me that this was an example of a real meeting of minds between the politician and the scientist.

Professor Porter: In some ways, very clearly this has been established. Because of the times and the severity of the problems the economy in the United Kingdom is facing, this partnership is perhaps at this stage being inhibited because it is constrained towards very specific goals. I would say that what is going on in Canada is a bit different. I like it rather more. I am thinking of what Mr. Yeomans is doing at the Treasury Board. This is a gradual influence—it is not a penetration, although you can look on it as a penetration, if you like. But it certainly is an appreciation on the part of the Treasury Board, that it is a very good idea to bring in technologically-oriented people to study budgeting problems. Normally you would bring in a chartered accountant, you would not normally bring in a professional engineer such as Mr. Yeomans. I like this sort of thing. The marriage may be slightly more illegal. Britain set up the Department of Technology and brought in an authority of Professor P.M.S. Blackett's stature because they were obviously in very real trouble with their productivity levels which are about two and a half times less than those in the United States. When you have innately such a constraint on a marriage of that kind it may be very inhibiting. It may be that the full worth of the interaction is inhibited, it is perhaps not given full rein.

During the past year I have been responsible for an interdisciplinary seminar at the University of Toronto—it capitalized on the abrasion that you get when humanists and scientists get together. If you can discuss problems from an inter-disciplinary viewpoint, as we discussed the science policy problems two weeks ago, it is a great help. I wanted the views of representatives of the humanities and of the social scientists, and this threw an entirely different light on the problem.

In the Ministry of Technology, specific goals exist and I find it very difficult to compare their activity in terms of what we are doing here. But the more we can compare them the better.

Senator Grosart: Somebody once said that if you look hard enough you will find a shotgun of some kind or other behind every marriage.

The Acting Chairman: That is a rather broad statement.

Senator Grosart: I qualified it, Mr. Chairman, I said that if you look hard enough you will find a shotgun of one kind or another. My question is: is there not something of a shotgun atmosphere in our present Canadian situation respecting productivity and so on? In other words, why wait until we get to the British situation before we insist on this marriage?

Professor Porter: Of course I agree. I agree entirely that we must anticipate the future. In fact, this is what evolution is all about. We, as a species, are predicated on uncertainty. We try to isolate trends and patterns until the message is loud and clear. I agree that we must anticipate these problems, and one way of anticipating them, clearly, is bringing up to date our science policy and letting it interact with other aspects of Canadian society. Perhaps the Economic Council and the Science Council should be combined. Perhaps we should set up a national institute for the social sciences and technology. Or perhaps we should set up a national institute for culture and technology and let exciting people in different disciplines interact. This is where the excitement is today. It is in these sorts of activities, but if we keep such people in watertight compartments, then we are not getting our money's worth.

Senator Hays: I suppose, Professor, that markets for the things that you are trying to do have a great deal to do with the direction in which you are going to go. I think of airplanes, for instance. It was a war market that gave us the reason for all of these improvements in that field, and the same is true of computers.

Professor Porter: Yes.

Senator Hays: And the same holds true for food. As an agriculturalist I think of the time when having a little bit of a market, it did not take us long to grow 850 million bushels. I think we could grow a billion and a half. So, in trying to assess the direction in which we may be going in the sciences, probably we should be—and I am wondering about your opinion—looking at the markets. Where do we need these things?

Professor Porter: International market research is absolutely basic, and this is all tied in with what I have been talking about when referring to information science, because we will not do it unless we have got very strong capabilities in these sorts of fields. We need people trained and educated as scientists and computicians, humanists and, certainly not the least, sociologists. It will be necessary to see what patterns there are, where the markets are, and how these will expand and what their implications will be for the Canadian economy and Canadian productivity. This is perhaps the first thing we must do.

In other words, how are we interacting with our environment, because this is what we are talking about when we are talking about the balance of payments. It is just this. Stuff goes out and stuff comes in. This now lends itself, I am sure, to objective analysis. That is what I am saying. But to what extent this is being done I do not know. It may be being done in the area of agriculture. There may be an international market analysis of this kind. It is a fascinating thought which had not occurred to me. I think it is a first-class idea.

The Acting Chairman: May I move into a completely different area? Again it may be out of order, but I have read from time to time recently views expressed by scientists in the fields of biochemistry, biology, genetics and that sort of thing, to the effect that not too far ahead they will be able, through genes and other matters of this kind, to influence and change human nature. Now, if that is true it has alarming possibilities. If it is just a pipe dream, it is a matter for interesting speculation. Have you come across this idea?

Professor Porter: I have, sir, and, like you, I do not feel very happy about the potential in this area. One is involved in a constant conflict between, on the one hand, the research related to the cancer problem and, on the other hand, research relating to modification of the genes. I am not a molecular biologist, but it is very obvious to me that here are two very closely related fields of research.

When I mentioned the great importance of interdisciplinary groups and the necessity for society to establish groups of this kind, these are the types of problems I had in mind, because governments may well—in fact in the long run will—determine or make decisions as to whether these researches continue. They are not going to seek advice from scientists alone because this would be biased. It would be biased because scientists are clearly oriented around discovering. This is their whole *modus operandi*. What these discoveries are and how they will be applied usually does not enter into the picture. I know many such scientists and they are not doing this willfully in any way. Their whole motivation is centred about a search for truth through discovery. That is why—perhaps for this reason alone if for no other reason—the importance of assessment by society is of profound significance. And, again, this might be on an international scale.

Personally, I would say that interference with the natural process of reproduction, interference with genes and chromosomes, would spell absolute disaster for mankind in the long run. I do not know how long it would take, but it is clear to me that this is something...

The Acting Chairman: That has to be contemplated.

Professor Porter: That has to be contemplated, yes.

Senator Grosart: Is there any evidence of such a situation having developed after Hiroshima?

Professor Porter: I do not know.

Senator Grosart: There was a great fear at that time. Were any studies of the problem made?

Professor Porter: I believe studies are still continuing, but I do not know just what has happened. I believe that so far as Hiroshima is concerned, and so far as early research into X-rays and radioactivity was concerned, the study was twofold. One aspect of it concerned damage to tissue. That is, vital tissue, obviously. The other aspect was the possibility of creating mutations, but, of course, mutations do not happen very often, and this, I am sure, is being watched.

Senator Grosart: Although mutations are often a natural part of the methodology of evolution.

Professor Porter: Of course. Completely. I do not know what the proportions of good or bad mutations are. We obviously are the result of good mutations, although one often begins to wonder.

Senator Grosart: It is a question of whether a giraffe is a good thing or a bad thing.

Senator McCutcheon: Professor Porter, I apologize for coming in late when you were giving your presentation. I had noted the hour incorrectly. You mentioned that we have instances where Canada has pioneered and then the application was not followed up, or it has been followed up outside the country. I know of one or two rather spectacular ideas that were developed at N.R.C. and which were later exploited south of the border because there were no Canadians prepared to exploit them here. How extensive by the results of N.R.C. research are made available for Canadians to exploit them, I have no idea, but apparently anybody there who knew about the technology knew about the patents. Have you any practical ideas as to how government can intervene effectively in that kind of situation?

Professor Porter: The way Britain is doing this, as Professor Blackett mentioned yesterday, is through the National Research and Development Corporation through which help is given to industry when it appears to the corporation that there is a potential in the economic field. This is certainly one mechanism.

Senator McCutcheon: Where the corporation is not prepared to take the full risk?

Professor Porter: Where the corporation is not prepared to take the full risk. In some cases it is 50 per cent of the risk. But in a few cases, mostly in the universities, I believe the development is a 100 per cent risk. In many cases, industry, of course, is expected to contribute; otherwise you get the situation that motivation drops a bit. However, if a government is going to pay the full shot, clearly there isn't quite the drive to speed up the operation. Now whether this would work in Canada, I don't know. I think it is an interesting thought. I had in mind when I was preparing these ideas for presentation having a director of assessment in this sort of area who would have with him qualified people capable of assessing and bringing people in as advisers, perhaps from industry. We have to do much, much more of this to get flexibility and to have opinions from a much broader sector. I would think of doing it in a rather amateurish way such as I was suggesting for Canada might be more appropriate. For example, I know of one or two areas right now in which I think we have a definite lead, but the full implications will not be felt, perhaps, for seven or eight years. I am referring now to the communications field. How much information can you put over a channel? There are two or three young men I know in Toronto who are doing some tremendous work in this area. If perhaps they could get some federal support, this would clearly speed up the whole development of these ideas. I know they are good because they were members of the same team that developed Canada's first solid-state computer.

Senator Grosart: Is this in the CATV field?

Professor Porter: No, this is in the field of information handling on the lines of the Datar project sponsored nearly 20 years ago by the Royal Canadian Navy. One of the reasons it has not been publicized much is that it was a classified study. In the United States many such projects are classified but usually in a comparatively short time the techniques developed are "spun off" into peacetime industry. The whole of the United States computer industry has benefitted greatly. Professor Blackett mentioned microminiaturization. This is an area which the United States space research program has stimulated in a very big way, and it is not only helping the space program and the defence program but it is also assisting civil programs immensely.

Senator McCutcheon: But do their research programs not largely cover the civilian field and does the information and the knowledge not pass there almost automatically?

Professor Porter: That's right.

The Acting Chairman: You mentioned the importance in the areas of what you termed massive research and international co-operation. Do you apply something of this same principle to what I would call higher level and expensive research within Canada in terms of having it more concentrated, if you like, in one centre or in two or three centres as compared with the kind of thing which I think Senator Carter had in mind of providing opportunities for larger numbers of smaller groups across Canada? You have a typical illustration of this in our universities. We have them scattered from St. John's to Victoria. Obviously they cannot all do everything.

Senator McCutcheon: You've got them from Simon Fraser to Victoria.

The Acting Chairman: If you like. I will agree with that.

Senator McCutcheon: I thought you would.

The Acting Chairman: How much importance do you attach to what I would call the principle of centralization versus the dispersion of opportunity? I realize it is not a yes or no question.

Professor Porter: In certain areas, of course, I would go with centralization for essentials. In other areas not involving heavy expenditures in capital equipment, perhaps it is not quite so essential. But apart from the humanities and to a certain extent the social sciences, especially I think the humanities—this dispersal is very good because it involves different kinds of libraries and different environments. In the case of science and technology, as I said before, you have to try and locate the centres of excellence and gradually see that these are built up across Canada. Maybe these will be centres of excellence involving government scientists, industrial scientists as well as academic people. This is a means of optimizing rare resources because there is the question of critical mass again. You must develop up to a minimum size for particular kinds of research and development and unless you do this then you are not going to explode and you are not going to get the regenerative process going. This need not be in any way inhibiting. This is not bringing more red tape into the situation. One normally regards centralization as creating, through the application of Parkinson's Law, a superstructure of red tape, paperwork and so on. This need not be; and, for example, does not happen too much, I think, in the universities. And anyway one can always mitigate this by using jet airplanes and using satellite communications so that one is both centralized and at the same time one is also non-centralized in one's activities. But when you discuss the mammoth projects, where you may be talking of sums in the tens and, perhaps, even hundreds of millions of dollars, then the time rapidly comes when you ask the question: Do we come to some agreement with some foreign nation for the utilization of their facilities? Or do we set up a facility here in Canada?

In some fields, the answer is going to be: We will do it in Canada, because this will evolve into an international centre. In others it may well be that we use the facilities in Europe or in the United States. Already this is being done. The University of Toronto Department of Physics is using the bubble chamber at, I believe, the University of Chicago, and there is a very close interaction. It is unthinkable that they would develop this facility at the U. of T. because of the excessive costs involved.

The Acting Chairman: Professor Porter, Senator Aird and Senator Sullivan have just come in. They did you and the rest of us the courtesy of sending a message, which I was going to read before we adjourned, to say that they were held up by fog in Montreal and apologizing for not being able to be here, but said they would as soon as it was physically possible.

Senator McCutcheon: That is a slander on Montreal. It was fog in Ottawa that held them up.

The Acting Chairman: They said they would be here as soon as physically possible, and now they have arrived.

Senator Aird: We do apologize. We came by limousine from Montreal, through very thick fog. On behalf of Dr. Sullivan and myself, we are very sorry that we are late.

Professor Porter: I am sorry too, senators.

The Acting Chairman: Now, honourable senators, it is nearly five o'clock, and I did suggest that we would have a very short business meeting. Unless someone has an urgent question to put, I am going to suggest that we formally adjourn, with an expression of thanks and appreciation to Dr. Porter for his very interesting contribution this afternoon, and with the expectation that he may be called back before us in due course for further discussion.

Senator McCutcheon: When we are in a position to ask him more intelligent questions.

The Acting Chairman: Yes, when we have learned more.

Professor Porter: Thank you very much.

The committee adjourned.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Thursday, March 21, 1968

The Special Committee on Science Policy met this day at 10 a.m.

Senator Norman A. MacKenzie (*Acting Chairman*) in the Chair.

The Acting Chairman: Honourable senators, like the rest of you, I am very sorry that our Chairman, Senator Maurice Lamontagne, cannot be with us this morning. I was talking to his wife last night, and she said that he seemed to be in reasonably good form though ill with the flu, and I urged her to insist that he stay at home for the rest of the week —which I think Senator Sullivan will agree is the best medical advice that could be given in the circumstances.

This morning we have with us the representatives of the Science Secretariat of the Privy Council, headed by its Director, Dr. Weir. With your approval, honourable senators, I will ask Dr. Weir and his colleagues to come and join us at the table.

I had the privilege of being a colleague and friend of the first head of the Science Secretariat, Professor Frank Forward of the University of British Columbia. I was also particularly interested in our Faculty of Agriculture at the University of British Columbia, for a variety of reasons, and because of that, and other circumstances, I have known about Dr Weir for many years, and I know that he is held in very high regard by his academic and scientific colleagues across the country.

Dr. Weir, I am going to ask you if you will be good enough, first, to introduce your colleagues, and then to make a statement on the work of the Science Secretariat. After that we will probably have a coffee break of about fifteen minutes and, if you agree, we will ask the members of the committee, or those who have been good enough to come and join the committee this morning from the Senate, to ask any questions that may be of interest to them or relevant to what you have said.

Dr. John Robert Weir, Director of the Science Secretariat of the Privy Council: Thank you, Mr. Chairman and honourable senators. At your request, I would like to introduce my two colleagues: Mr. G. McColm, from the Secretariat, who is responsible in our operations for the statistical and economic analyses related to science; and Dr. Ray Jackson, who joined the Secretariat almost at its beginning and who has had past experience in the physical science field and has recently been giving a great deal of thought to science policy, working on staff studies in the Science Secretariat.

I think I should say also, Mr. Chairman, for the information of honourable senators, that unfortunately—and certainly unfortunately for me—two of my senior colleagues are unable to be here today. Dr. Whitehead is just completing an immersion course in French, and so cannot be here; and Dr. Munroe is also unable to attend.

May I say, first of all, Mr. Chairman, that I consider it a very great honour to represent with my colleagues the Secretariat at this meeting. We are privileged to appear before this committee. We have been particularly interested in the formation of this committee since we first heard of it, because we feel that it represents a forum in which science and technology can be discussed at a very effective level.

I feel that the one thing that has been seriously lacking in Canadian science is a definition of its character. This is not an instant happening, I would suggest, and it will come about only when we have much improved communication among scientists —although this is reasonably satisfactory at the present time—communication between those engaged in scientific activities and those people, like yourselves and the members of the other house, who are responsible for policy matters in government, and also communication between both of those important bodies and the public. It is only when we have an active forum for discussion and understanding that I think will evolve a character for Canadian science with which we can identify ourselves, and I think that that will be extremely helpful in our future planning.

I know that you have received previously in this committee a considerable amount of information about the development of science in Canada—its historic development—from Dr. Mackenzie, and you have also heard a discussion by Dr. Solandt of what is being done by the Science Council. I thought that at this meeting, Mr. Chairman, I should confine myself to discussing or describing the functions of the Science Secretariat since it was formed, and some of the activities it has undertaken, and some of the changes in emphasis and direction that have occurred through its evolution and involvement, and, if possible, through this to try to give some of my own comments or attitudes towards the broad picture of science.

When I am speaking of science, gentlemen, I am speaking of it in the broadest context—a context involving the broad and interesting field of innovation associated with research and development, and the direction of this in connection with the economic and social aspects of the country. So, I am using "science" in its broadest sense. I would like to comment on certain aspects, but this in a broad way.

Mr. Chairman, since the Secretariat is reasonably young, and since, as I have said, there have been changes in its development, and some of its work and studies are coming to, I hope, a successful fruition, it is possible that our thinking regarding the broad aspects of science may mature and develop through the next few months, and possibly we shall have an opportunity, by either written submission or appearance again before this distinguished committee, to be more positive and definite.

Senator Pouliot: Mr. Chairman, I have just one question to ask, with your permission, although I am not a member of the committee. The witness has said that the Secretariat is young. I would like to know in what year it was formed.

Dr. Weir: This, Mr. Chairman, brings me to the development of the Secretariat. It was brought into being in July, 1964.

Senator Pouliot: 1954?

Dr. Weir: No, 1964. The Science Secretariat arose from one of the recommendations of the Glassco Commission. A more detailed study made by Dr. Mackenzie at the request of the Prime Minister supported this idea of a science secretariat, and recommended further that it be placed in the Privy Council office. The Prime Minister announced in the House of Commons on April 30, 1964 the establishment of the Science Secretariat, and perhaps I might quote from the Prime Minister's statement a sentence which I think summarizes the responsibilities that were given to the Secretariat:

> ... to assemble, digest and analyze all information concerning the Government's scientific and technological activities and their inter-relation with university, private industrial and similar provincial scientific establishments.

As I said, Mr. Chairman, it actually came into being on July 1, 1964. It has at present an authorized establishment of 27 professional, and 13 sub-professional, positions. Until the passage of the Science Council of Canada Act in 1966 much of the attention of the Secretariat was devoted to the preparation of legislation, and advising on the establishment of the Science Council. So, one of the first tasks it was asked to perform was that of giving assistance in the procedural steps in the development of the Science Council.

The Prime Minister outlined its responsibilities in a broad and general way. As I have mentioned before, the emphasis within these responsibilities has tended to change with time, until at the present time I think I can say that its activities lie in four general areas. It has responsibilities in the Privy Council office because its members are members of the Privy Council office. It has activities in respect of the Science Council of Canada, and I will develop these more fully later. It also conducts its own studies, and it has responsibilities in the field of international science policy activities. Its main activity at the present time is that of supporting the Science Council and enabling it to obtain background material for studies in respect of the formulation of policy recommendations.

Within the Privy Council office—perhaps I might take a minute in which to enlarge our activities here—its primary function is to act as the scientific component of that office. In this respect it is a source of information, on a day to day basis, on scientific matters for the Prime Minister, the Privy Council, and cabinet committees and cabinet secretariats. It participates also in those planning functions or activities in the Privy Council office that have primarily to do with science and technology. One of its major efforts in this respect recently was the organization and direction of a task force to commence the planning in respect of a part of one of the recommendations of the Science Council of Canada on upper atmosphere and space research. In this connection it had to consider its activity on a very broad base. The task force took into account social, economic, legislative, and institutional factors that enter into this very broad and complex problem.

The secretariat also has a key role in identifying scientific and technological issues that are important in national policy, and in providing a dimension of scientific judgment to the central agencies. As a purely advisory body, with neither operational nor granting funds in the scientific area, it is well constituted to act as a neutral arbiter in science questions and to act as a focus for interdepartmental and interagency discussion and co-operation.

Respecting its activities in support of the Science Council of Canada, the Science Secretariat has been instructed by the Prime Minister to provide secretariat and other supporting services to the Science Council, which is not an agent of the Government and has no support staff of its own. The support provided includes secretariat services proper: the full time secretary of the council, administrative, stenographic and publication services and offices in Ottawa. It also includes a rather extensive array of supporting studies at the present time, which occupy the full time of eight professional people and a number of sub-professionals. It has a contract staff of over 200, both professional and sub-professional people, engaged principally in seven active studies. The support of the Science Council in this respect is by far the largest activity of the secretariat in both manpower and budget.

When the secretariat was formed one of the early problems which arose with us in this advisory capacity was a lack of sound information on the present status and activities of science in Canada. We therefore thought one of our first objectives should be to try to get an inventory of the scientific work being done in this country at the present time. On looking outside the country at similar research organizations which had been established before this we were further convinced that this was an essential first step. We therefore started a number of studies of an inventory nature attempting, as far as our manpower and financial resources permitted at that time in a developing unit, to try to cover the field of science.

These studies were organized in two general ways, one on a discipline basis in science. We conducted a study in physics in Canada, and currently have under way studies in chemistry and biology, as well as our studies on a usage basis, such as our upper atmosphere and space study, our current study on agrculture, on water resources and scientific and technological information. The discipline studies are largely inventory and give the state of the art, and in addition to this the usage studies tend to extend into the field of organization, with possible recommendations in this regard.

It was our hope to cover this field in three years if we could, because we thought this would give us an opportunity to look at the picture with comparable figures and have a base on which we could conduct further studies. It would let us know where in the country our strengths were, where our weaknesses were and what might be the position if we decided to change emphasis or direction.

When the Science Council came into being we had to consider a relationship between the Science Council and the secretariat, and it seemed appropriate to us and to the council that most, if not all, of the studies should become council studies, because out of this basic information would come the background required to develop science policy. We also felt as part of getting a discussion of science in Canada we should as far as posible publish the reports of our study groups and task forces as they prepare them. We have done this as background material, and the actual document would be a much shorter report from the Science Council emphasizing policy recommendations in general. We have therefore had a period of transition and readjustment in attempting to fit these two organizations together to be complementary to one another.

That is some of the background to these studies. Our study in physics has already been published, and that in upper atmosphere and space. Our agriculture study we expect to be published in June this year; our basic biology in September, 1968; the chemistry study is expected in April, 1968; we also have under way an engineering research study in three sections, having a university component, an industrial component and a government component, and that is expected in June of this year. One if not the most important of our studies, in my opinion, that we have under way is a study on support of research in universities, headed by the successor to your chairman as president of the University of British Columbia, Dr. John Macdonald. This is being done for the Science Council of Canada but is being administered by the Science Secretariat.

The Acting Chairman: Can you say when that is likely to be completed and published?

Dr. Weir: I am always cautious and disappointed when I make statements on this because I am always wrong. Our hope is that it will be completed by the end of the year.

The Acting Chairman: The end of 1969?

Dr. Weir: The end of 1968.

The Acting Chairman: Not before that?

Dr. Weir: No.

Senator McCutcheon: Give or take a year!

Dr. Weir: This is one of the dangers, senator, but one thing I have found is that when we are doing this with consultants there is a terminal point on which we end, and this has been of some assistance.

Senator Aird: Your other reports have been on time, have they not?

Dr. Weir: Yes. The staff work has been done on time so far, I think, in general. We have had some difficulty in meeting deadlines on publication because of difficulties in getting printing and translation done, and matters of this nature. In general, our reports have been on time, except when an agreed change has been considered necessary and approved. But we have been quite happy so far with this.

Senator Pouliot: Could you summarize what your secretariat consider as consultants?

The Acting Chairman: Could we leave that for a moment until the witness has completed his work. We have your name on the list.

Senator Pouliot: Thank you.

Dr. Weir: I might say that partly in this respect we have the terms of reference of the various studies here for your information. I think these will outline the scope in which we have asked our consultants and our staff to work on these problems. I hope it will define the scope of the report when it comes in. So this might be of some interest and assistance to you.

I should like to say something more about these studies, and support of research in universities at the present time. We first discussed the need of this in the secretariat in 1966. When the Science Council was established it was brought to the Science Council at its fourth meeting in January 1967. The Council agreed this was a very necessary and needed study, so it established a study group under the chairmanship of Dr. Gaudry, Rector of the University of Montreal, whose eventual purpose was to receive the report of the study group on behalf of the Science Council and to frame recommendations based on that report, for consideration by the Council.

It may be I should stop here for a minute and mention something about our attempt to tie the Secretariat and the Council effectively together. When the Council accepts a report or a study it establishes a Science Council Committee to follow this study. Usually the chairman of this Science Council Committee is a member of the Science Council, it is highly desirable that he be; but in a field as broad as science it is sometimes difficult to get somebody on the Council with the time and the expertise to handle this. We have departed from this once in the water resource sector. Other than that, as it is desirable, and wherever it is possible, the chairman of the Science Council Committee is a member of the Science Council. It usually has a membership of seven to nine, although in university studies, for other reasons, it is much larger than this. Also on these committees usually there are about four members of the Council, and we bring in three people who are experts and interested in the particular field, outside the Council itself. Therefore, in all these activities we have tried in the Secretariat, by the use of consultants and by the composition of the Science Council Committees, to attempt to involve as much of the scientific and technological community in our work as we can.

Senator McCutcheon: At what stage are those committees set up? When the project is authorized or when your work has been completed?

Dr. Weir: From now on, the committees will be set up when the study has been authorized. There have been various stages of this in our past history, because we have had evolutionary development, and some of our work was under way and was taken over by the Council. The system has been evolving as well as the studies.

Senator McCutcheon: From here on, your Council Committee will be au fait with matters as the study goes on?

Dr. Weir: When the Council approves the study it also approves the terms of reference and follows the study through the conduct of the study. These are for Council studies. There are other studies which we undertake for other reasons in the Secretariat and which are not in this category.

Might I also say that we usually get the study approved in principle, that this is a field we should study; then we try to get some senior person who has expertise in this, to do a preliminary outline of the study and develop the terms of reference. Then the terms of reference are discussed by the Council, accepted or modified; and then the study proper begins by the consultants under the direction of the Secretariat. In many instances—and I think it most desirable, if possible—the consultant who has done the terms of reference and the original work often is the one who heads the study group.

Senator Aird: Are there many areas that are done independently by the Secretriat? You mentioned that there are two types of study going forward, one under the authority of the Council and some you do independently by the Secretariat. What is the relationship?

Dr. Weir: Most of the studies we do in the Secretariat that are not Council studies are at the request of the Government. They involve studies on matters on which the Government wants advice and they involve production of information and recommendations for planning and decisions of Government. The Science Council is a public body. Therefore, it is engaged in a broader kind of study. Most of our studies that are not Science Council studies are in this realm and this of course distinguishes between our responsibility to the members of the Privy Council office and those of providing a secretariat for the Science Council on the other hand.

Senator McCutcheon: Such studies would only be published with the approval of the Government?

Dr. Weir: As far as those studies are concerned that are ordered by an agent of the Government, who approves the study, that is so.

Senator Belisle: It remains confidential information?

Dr. Weir: It remains confidential information—and these are activities of the Privy Council office group. This does have some difficulties at times, but I think the problems of money expenditure are some, although they may be administrative, but they do bring us face to face with some of the real problems. We are still in an evolutionary stage in this respect.

I wish to outline to you the methods by which the Council has conducted its studies. A committee holds meetings with the task force or study group or consultants at regular intervals and therefore gets keyed into the study and can bring its broader influence in an advisory consultative capacity into the conduct of the work.

I should say here that the picture or the situation may change regarding these studies. It is one thing to be conducting inventory studies which simply tell you the state of the art. Most of those studies are not anywhere in real decision making or debatable level. But when we get into studies involving major science policy issues, then we probably are going to have to change from a broad consultant basis to more staff studies in more depth. The Science Council may become more intimately involved in this. In our inventory studies to date we have employed a number of techniques. In three of our studies we have subcontracted to professional bodies, the Canadian Association of Physicists, for research in physics; the Chemical Institute of Canada, for research in chemistry; and the Biological Council of Canada, and the Canadian Federation of Biology for research in biology.

We felt that here we could make the greatest use of the wide community of scientists in Canada and also attempt to bring them into the picture of the kind of studies we are doing. We have also done studies directly under consultants under our own intimate direction, which is our main method of doing it.

If I might come back for a moment to university support of research in the industry, I would say this: It soon became evident that the setting up of a national policy for support of research in the universities could not be accomplished if only the natural sciences and engineering were to be considered. After much consultation, it was agreed that the study should be formally co-sponsored by the Science Council of Canada and the Canada Council and that both the committee headed by Dr. Gaudry and the study group headed by Dr. Macdonald should be expanded by the addition of some distinguished representatives of the social sciences and the humanities. This has been accomplished and agreement on all sides has been reached on a set of terms of reference which is as far as we can go at the present time. These terms demand that the study group look into the support of all research in the universities and that the group in particular consider and report on:

1. The present levels, sources and conditions of financial support in the universities.

2. The broad purpose and objectives of the Government and the universities that should be served by the research support program.

3. The principles and policy that should be adopted in attaining these objectives.

4. The organization, mechanisms and management policy that will best meet the principles and objectives that are defined by the study.

During the discussions that led to the decision to cover the social sciences and humanities as well as the natural sciences and engineering, it rapidly became evident that there was no ordered body of statistical data readily available to cover the federal support of research in the social sciences and humanities. In contrast to this, the Dominion Bureau of Statistics have for many years provided useful data on federal support in the natural sciences and engineering.

Since some knowledge of the present level of support, no matter how inadequate it may be, was required by the study group, it was decided to commission an investigation of the current levels of such support. The Ontario Institute for Studies in Education have agreed to undertake such an investigation and will be making a report to Dr. Macdonald's group by the end of the summer.

The study group have chosen to approach their task by two means, firstly, by soliciting briefs from the universities in answer to the general questions raised by the terms of reference of the study; secondly, the study group have conducted a comprehensive series of visits to practically all of the universities in the country during which discussions were held with both senior members of the university administration and the academic staff. These visits have given the study group a broad look at the many problems being faced by the universities in the face of the rapid expansion of the research efforts within their walls.

Mr. Chairman, I am taking just a few minutes to particularly give you some of the details of this study, because I think this is one of our important studies at this time. We will in any program have to look at the place in which the universities are in the Canadian picture, and it may give us reasons for quite serious consideration of some further studies in planning our deliberations.

The study group have now completed their visits to the universities and are nearing the end of visits to federal departments and agencies. They now face the task of coming to grips with a wide range of questions.

If I might, I will just mention to you some of the questions they are asking themselves, because you may be wondering about these in your own minds already. So far as I am concerned, there is certainly no answer to these questions at the present time. I would be prejudging the report, if I were to say I knew the answers. I do not. I believe the members themselves have not reached that stage as yet, but they are asking certain questions: What are the objectives of the universities in research?

What is the appropriate role for the federal Government in supporting research in the universities?

What is the future of the three major granting councils?

When the Government decides to establish new laboratories what relationship should these laboratories have to universities?

How should our granting mechanisms cope with the funding of interdisciplinary studies?

To what extent should efforts particularly in applied fields be co-ordinated towards national objectives and what means of coordination are available? Together with these broad questions which must be answered within the framework of a national policy there are also other very specific questions to be tackled. Should the federal Government pay overhead charges when it provides grants or contracts to the universities?

Should the federal Government provide funds for the construction of buildings which will be used wholly or even partly for the conduct of federally-funded research programs?

At the present time it is hoped that Dr. Macdonald and his study group will be able to present a preliminary report to Dr. Gaudry's committee by the end of the summer. Sometime later in the year the Science Council and the Canada Council will then present their recommendations for any appropriate changes to the federal mechanisms for supporting research in our universities.

I do not intend to go into any of the other studies at this time. As I said, the terms of reference are available. We have in addition an inventory study on transportation research and water resources research. I would also mention that the Science Secretariat has commissioned a study group on scientific and technical information in Canada with more than 30 members and consultants under the chairmanship of Mr. J. P. I. Tyas, who has been seconded from the Department of Industry.

Senator McCutcheon: What is the status of these inventory studies? These are deemed to be committed by the council so that they will be published?

Dr. Weir: Yes.

Senator McCutcheon: Good.

Dr. Weir: I expect there would be two publications—the council publications, which would present recommendations on policy and the study group report, which I hope would either be published as a background study, as done in the past, or would appear as an appendix to the Science Council report.

Senator McCutcheon: It is not regarded as classified?

Dr. Weir: No. If any of you wish to see either of these two reports we have done, if you have not already, I have copies here.

Senator McCutcheon: I was going to suggest to the chairman that copies might be circulated to the members.

The Chairman: That will be done.

Dr. Weir: If I might, just for a minute, Mr. Chairman, I will turn to our responsibilities in so far as international affairs are concerned with respect to science policy. With the rapid increase in government funding of research and development in recent years, the governments of nearly all of the advanced countries have become increasingly concerned with the balance of their scientific effort and with the question of priorities in research and development. Many countries, like Canada, have re-examined the organization of their scientific activities and established new advisory bodies, or Science Councils, with no operating responsibilities. Associated with the new advisory councils are science secretariats which provide the information upon which advice is based. Our Science Secretariat since its inception has followed closely these developments in science policy in other countries.

I might just mention something about our relationship with the OECD operation. That is the Organization for Economic Co-operation and Development.

The Science Secretariat's first formal association with international scientific affairs came in November, 1965, when the Hon. C. M. Drury, as Chairman of the Privy Council Committee on Scientific and Industrial Research, asked us to assume responsibility for preparations for the Second Ministerial Meeting on Science. One outcome of this meeting was the creation in 1966 of an OECD Committee for Science Policy on which the national science policy organizations of all member countries are represented. Members of the Science Secretariat have attended all meetings of this committee, accompanied by representatives of other organizations when the subject matter warranted—that is, people from the National Research Council and Department of Industry, and from other departments where there were appropriate reasons for them to be there.

The OECD Committee for Science Policy has been responsible for preparations for the Third Ministerial Meeting on Science which was held in Paris on the 11th and 12th of this month. Senator J. J. Connolly, the leader of the Canadian delegation, has already provided the Senate with an excellent report on this meeting. However, for the record, I should say that the three major agenda items were:

(a) technological gaps between member countries;

(b) the promotion and organization of fundamental research; and

(c) scientific and technical information systems and policies.

As might be expected from the subject matter, much of the Canadian background material was provided by the National Research Council and the Department of Industry. Prior to the meeting, the Science Secretariat also consulted the Advisory Panel on Scientific Policy, which is a committee made up of the deputy heads of the science-based departments and agencies of government, and then following consultation with the various people in scientific departments and agencies attempted to bring what might be called a Canadian point of view on these three important and major subjects.

The Canadian delegation intervened in all three subjects, and as Senator Connolly reported brought in a resolution on the scientific and technological information study recommending that a task force be set up immediately to study this on a member country basis. The O.E.C.D. countries represent approximately 75 per cent of the research being done in the world. They recommended that they attempt to establish an international focus on this very important subject, and that member countries try to develop their own focus. We had already started on this and I think have come quite a distance by our task force's study of scientific and technical information. It was, of course, done previously and our interest in this field made us participate in this international field.

We also, as a secretariat, were asked to assume the responsibility for the scientific attachés at our foreign embassies. We have four of these attachés at the present time. One is in Washington, one in London, one at our embassy in Paris, and one at the O.E.C.D. mission. In the future these people will be on the staff of the Department of External Affairs and will report to the head of mission, of course. The Science Secretariat will recommend the appointment of these people and recommend the type of work and the actual activities of these people when they are on postings.

I think, Mr. Chairman, I have been taking up a considerable time, but I would just like to say that there are a number of things that come to my mind at the present time. I think that one of the major actions and responsibilities ahead of us is to, through the appropriate agencies, attempt to define what best we can do in determining what might be a national goal for science in Canada. This is a very simple thing to say, but it is a complex thing to discuss. I think we have to identify those areas of research in this country that will be of particular benefit to Canada, not only in our development of the country but in our economic development as well.

I think we have to consider in this context and in these areas the development and support of, for want of a better term, "centres of excellence" of research where we are really in the lead. I think we also have to consider in what areas we must do research because the resources that we have will naturally require us to do it for national development such as in the field of renewable resources. Certainly in a country such as Canada one could hardly imagine not having a competence in agriculture, fisheries, forestry and water resources, and in non-renewable resources like minerals and metallurgy.

I am sure one could expand this into its social and economic implications in this field which are tremendously complex. In addition to this and partly related to it we have to decide as to the emphasis we are going to place on the different parts of the spectrum of research and development. I think we have to give thought as to the support we are going to give to pure research, to basic research—and I know these terms are used in many different ways by many different people—basic research in the field of mission-oriented areas, to applied research to developmental research, even too to the production of prototypes where this can be done. Because unless we can direct a very substantial part of our research program toward economic and social development of this country, I think we will be in trouble and I think it would be very difficult to get the means by which we can continue to do research. So we have to look at these problems from that level.

Another thing I think we probably have to give some thought to today is this area of science that the Science Council and we in the Science Secretariat are interested in. That is the broad concept of science policy and planning that must be done outside operating departments. I think that we certainly have a natural place to plan the actual research program from an operational sense in departments and agencies of special interests in this general area. But there are times when one has to look at the whole picture in a country such as ours and give some thought to and do some research into what the total picture is and the many complications there are going to be.

I think this is best done by an organization or an agency that does not have responsibilities in the operating area. I think it can divorce itself and assume as neutral a role as anybody can assume in this general picture. I think this is one thing in this country that we do need—some kind of planning agency or some sort of organization outside of the operating areas who will be able to plan programs and approaches and discuss this from a very broad point of view.

Senator Aird: Are you suggesting that this non-operational agency should be a priority choosing area?

Dr. Weir: I think it should be a priority advising agency.

Senator Grosart: Is the Science Council not doing this now?

Dr. Weir: Well, it is developing in the field of advising on permanent policy and on priorities, but there comes a planning phase between when these policies are recommended and when they are accepted. As to the planning of these policies for implementation and consideration—this is the area that I think is going to become of increasing importance, and particularly we have other factors entering into this as well. I think I could say that in the past, at least, our university organization, Mr. Chairman, has been largely on a science discipline basis; that our governments traditionally have been largely organized on the usage basis, except agencies that have been set up for specific purposes. Much of our research and much of our thinking at the present time are in areas that require an interaction of these things and an interdisciplenary approach to solving the problem.

Senator Sullivan: Is this still not overlapping the Science Council with your own body?

Dr. Weir: That respect of the Secretariat's activities that has to do with planning in the government is not part of the Science Council's activities.

Senator Sullivan: Thank you.

Dr. Weir: The extent to which this is so, is another problem. We have evolutionized into some of these activities.

Mr. Chairman, I think I have perhaps been a little incoherent in some of my development on this but, rather than follow too closely the prepared material, I have attempted to paint it rather broadly.

The Acting Chairman: It has been very interesting, Dr. Weir. Would either of your colleagues like to add to what you have said?

Senator Belisle: Could we ask questions before we come to that, Mr. Chairman?

The Acting Chairman: I was going to suggest that we might have coffee and then come back.

Senator Grosart: A good idea.

The Acting Chairman: I was wondering whether either of your colleagues wanted to contribute anything. If so, perhaps that could be done immediately after the recess, followed by questions.

(*Short recess*)

UPON RESUMING

The Acting Chairman: Honourable senators, if you will come to order we will proceed with the meeting of the committee.

At the moment the procedure is that Senator McCutcheon will commence the discussion, and Senator Belisle has asked to be allowed to ask a question, followed by Senator Pouliot, Senator Hays, Senator Aird and Senator Grosart.

Senator McCutcheon: Mr. Chairman, I must confess that I am confused by the latter part of Dr. Weir's evidence. It seems to me that he was recommending the establishment of a third advisory body in this field. I wonder if you could help me out on that, Dr. Weir?

Dr. Weir: Mr. Chairman, Senator McCutcheon, maybe I should just take one minute to develop this or to say another word or two on the Science Council—Science Secretariat relationship.

One has to appreciate that the Science Council is composed of very busy and very senior people, who usually devote one or two days every couple of months to Science Council meetings; and I am sure they do a great deal of work in between as well. But, even at best, this is a body whose thinking and whose interest really is not their prime responsibility. So, therefore, the Secretariat really has to be the professional side of this, and has to develop much of the background for the Council to discuss. The Council is a public body, it is not a government body; and its responsibilites are to advise on general priorities, national goals, general policy.

Senator McCutcheon: And it gives that advice and makes those recommendations public?

Dr. Weir: Yes, it makes these public, and can advise the Prime Minister in respect of these.

Then, if the government accepts one or more of these recommendations, there comes a stage of further planning, the refinement and the framework of these recommendations. One way of further refining and identifying specific areas would be, as has been suggested in the Science Council, the establishment of task forces of qualified people in these areas, to reduce these to a much more refined state. But, if this is to be a part of government implementation, there must be a lot of planning done regarding present government activities, departmental activities, emphasis within the government itself. In general, it is the lack of this, I think, that will be a gap between agreeing to recommendations and putting them into effect.

Senator Grosart: Does this come before or after the political policy decisions?

Dr. Weir: Well, I think the political policy decision would almost require this information as background material in this regard.

Senator Grosart: Except that you cannot start doing things until you have a political policy.

Dr. Weir: It certainly has to be a component of it—and an economic policy.

The Acting Chairman: Do you have something to add, Dr. Weir?

Senator Grosart: I am sorry.

Dr. Weir: Yes, Mr. Chairman. I might just say that we have already done part of this in our task force in-house work on the domestic communications satellite. I am sure other things are going to come up. This was an *ad hoc* situation but, in addition, there are other kinds of planning within this environment; it is this central planning aspect of government.

Senator McCutcheon: I would have thought that might be a function you would continue.

Another point I want to come to is how you feel the position of the Secretariat has been affected by its being directed to provide services and facilities, scientific or otherwise, to the Science Council. Is not the Secretariat in a rather ambiguous position? You are preparing and supervising studies to go to the Science Council which, by and large, will be published, and the Science Council will be making recommendations based on those, and they will be matters of public knowledge and quite easily matters of political debate. At the same time you are acting as the advisers to the politician and providing him with recommendations and studies which may or may not be consistent with what you are providing to the Science Council. I think you could find yourself in a very ambiguous situation.

Dr. Weir: I agree with you, sir, very much.

Senator McCutcheon: What is the reason—or, is there any reason, other than the fact that the Secretariat was there—why the Science Council should not have an expert full-time professional group working for it, just as the Economic Council of Canada has? You could still use your basic forces. You could still contract out particular jobs and call on all the talent that there is in the country, but you would at least know where your loyalties were.

Dr. Weir: The present situation, I am sure, stems largely from Dr. Mackenzie's original recommendation, and in his...

The Acting Chairman: That is the other "Dr. MacKenzie".

Dr. Weir: Yes, sir.

Senator McCutcheon: You have given up that title, Mr. Chairman.

The Acting Chairman: Yes, I surrendered it with reluctance.

Dr. Weir: His recommendation was, if I interpret his thinking correctly, that the Secretariat by being in the Privy Council office, and being a secretariat to the Science Council, could supervise and conduct the studies on which the Science Council wished to place its policy, and at the same time be a part of the planning within the Government itself. In other words, one could look out through the Science Council and look in through the Secretariat.

Senator McCutcheon: There was only one fellow who looked both ways, and his name was Janus.

Senator Grosart: And Lot, also.

The Acting Chairman: You mean Lot's wife.

Dr. Weir: This is a problem. In certain countries this is met by having one person who must wear a number of hats, and if you are successful this does give co-ordination. I think that on that basis, from the Secretariat's point of view, it must consider its work with the Science Council as a body responsible for carrying out the studies for the Council, and providing them with adequate background material, and the Council committees with their chairmen develop the recommendations, and the Council itself approves these recommendations. The chairman himself is the person who must assume the responsibility for the recommendations of the Council.

Senator McCutcheon: Do you regard your first priority as being that of the services you provide to the Council?

Dr. Weir: It certainly takes up the time of very much of our staff at the present time.

Senator Hays: That is, the Science Council?

Dr. Weir: Yes. I do not think the Science Secretariat should ever become a policy-making body for the Science Council. This would defeat the purpose of the Science Council. I think it is the responsibility of the members of the Science Council, and the responsibility of the chairman. I can quite see where it would be possible that the Director of the Science Secretariat, by the fact that he is in the Privy Council office and of necessity has access to more privileged information than the Science Council has in its public studies, might find it necessary to not have the same line of thinking, but that is his responsibility at that time and place.

The Acting Chairman: But you do have, in a sense, two masters?

Senator McCutcheon: It would be quite improper for me to ask if you were asked to advise the Government, and I shall not ask that question, but I am thinking of the HARP project which was a matter of some political debate, and I am thinking of the evidence given before this committee by the Chairman of the Science Council a week or two ago in which he said he regretted what had taken place in connection with that project. That is the sort of situation in which I feel you would be put in a very difficult position. I think you should either be working for the Prime Minister, or for the Science Council. The Prime Minister probably does not need a large science secretariat, such as that that has been established. Maybe he needs only one or two well-qualified advisers, and your much larger organization could be working full time for the Science Council, just as the economic and financial organization of the Economic Council works full time for the Economic Council.

Senator Hays: Mr. Chairman, it seems to me that you have got to get your direction from somewhere. You have to work for somebody. You cannot pass one off against the other.

Senator Grosart: Could I ask a supplementary question?

The Acting Chairman: Is it on this point?

Senator Grosart: Yes, it is on the point raised by Senator McCutcheon. Dr. Weir, do you consider it within your terms of reference to give the Government unasked advice on scientific policy, if I may put it that way—or, am I asking you to make a policy statement? Is it within your terms of reference?

Dr. Weir: Yes, I would say it is.

Senator Aird: May I ask a supplementary question, Mr. Chairman?

The Acting Chairman: Is it on the same subject?

Senator Aird: Yes, it is following Senator McCutcheon's question. Unless I misunderstood your reply to him earlier, Dr. Weir, I rather took it that you felt the secretariat might be the implementing body as well as the suggesting body to the Council. Is that a correct interpretation? In other words, after the political decision has been made and the priority has been established, you felt that some non-operational agency would be best suited for the implementation as well as the recommendation?

Dr. Weir: Yes, I do, and this is to some extent related to Senator McCutcheon's point about our operational role. I consider that our responsibilities to the Science Council are to perform in the best way that we can the administration of the steps that the Science Council requests. The Science Council establishes its committee and approves the study. This committee with its chairman accepts its terms of reference, follows the study, and prepares its report. This is all the responsibility of the members of the Science Council. This is not the responsibility of the Director of the Science Secretariat.

Senator McCutcheon: But the Science Secretariat forms a good many of those steps for the Science Council?

Dr. Weir: Well, it does the staff work.

Senator McCutcheon: Well, it does much more than the staff work, unless you call research staff work. I suppose it is.

Dr. Weir: Yes, but the acceptance and approval of all the decisions and the recommendations is the function of the Council, and not that of the Director of the Secretariat.

Senator McCutcheon: What happens if the Council commissions you to make a study in a field in respect of which you have already been asked for advice by the Prime Minister, and you have given advice which you have reason to believe the Government adopts? Does not that condition any staff work you are going to do for the Council?

Dr. Weir: Well, in that case, if the Council requested a study made under those circumstances, it would approve the study, it would approve the terms of reference, it would approve the consultants, and we would do the administrative work for them. They would accept the report, and it is their responsibility.

Senator McCutcheon: You must have a mind that can separate itself into compartments much better than mine. I am afraid that if I were proceeding to carry out what the Science Council asked me to do I would be conditioned by the advice I had previously given to the Government. I would be irresistibly motivated to prepare material which would lead the Council to give the same advice that I had given.

Dr. Weir: There is one other point in respect of this, senator. If a recommendation is accepted most of these recommendations would involve considerable planning within the Government itself. You can have your choice of asking the appropriate existing operating department to do this planning, and in many scientific activities today there is more than one, usually several, departments involved who may have the major lead. The feeling has been expressed that there is some problem when an operating department is asked to plan something new, something which involves other departments, that this is often done by a non-operating department. This is why we were asked to supervise and do the task force work on the space program. If you get into the planning side of things a great deal of staff is needed; it requires more than one person with a couple of junior advisors.

Senator McCutcheon: I appreciate that.

Dr. Weir: It is a sizeable operation.

Senator McCutcheon: That is right.

Dr. Weir: It is this side of our activities that requires strengthening.

Senator McCutcheon: The whole thing may work out satisfactorily in practice, but I am concerned that you should appear—although I do not see how in your dual role you can—to be as objective as I am sure you want to be. Appearances are frequently as important as the facts. I think that is all I have to ask.

Senator Belisle: I think I share the views of other senators, that it is not at all clear where these people sit in the diagram of authority. Before I ask two or three questions I should like to say this. Is it possible, Mr. Chairman, to have a diagram of who is whom? I believe we start with the Government, then the Privy Council and then the secretariat. The secretariat was formed in 1964. Is it first in authority before the Science Council and is the Canada Council next to it, or is the Privy Council next to it?

The Acting Chairman: I was going to ask the same question in due course.

Senator Belisle: Where do you go from there?

The Acting Chairman: Could you or one of your staff draft a chart for us setting out what in your opinion is the line of work?

Dr. Weir: We can supply that. We have a chart for that purpose. I should like to make a comment on this. There is no act establishing the Science Secretariat. There is for the Science Council. The Science Secretariat was created by an announcement of the Prime Minister and the appointment of members of the Science Secretariat to be Privy Council officers. We are, therefore, Privy Council officers. We work as a unit in servicing the Science Council for its needs and studies and provide the requirements of the Privy Council in its operations. We are a unit of the Privy Council.

Senator Belisle: Then are you responsible for having suggested to the Privy Council that the MacDonald financial committee be formed, and do they advise you or advise the Canada Council? I understand the Canada Council have the power to give grants.

Dr. Weir: That is right.

Senator Belisle: Did you suggest to the Privy Council that it should be formed to study the matter?

Dr. Weir: In the initial stages, in our early thinking in the secretariat before the Science Council was formed, looking at what we should do in our operation as a secretariat to get the information we needed, we felt that the support of research in universities was one of the important topics which must be looked at. We needed to get the information in this area. Before anything active was done the Science Council was formed and we had the intervening phase, the transitional phase, which is still not quite completed, in which we had started many things that the Science Council agreed should be done and took over. They accepted the university study as one of their major studies, appointed the chairman of their committee, Dr. Gaudry, and approved the selection of the committee and terms of reference. The Science Council made the arrangement to have a joint project with the Canada Council in this study.

The administrative operation of Dr. Macdonald's group is under our jurisdiction, since we have the budget and the administrative procedures to do this. Dr. Macdonald will submit his report to the Science Secretariat who will submit it to the Science Council. In the meantime the Science Council's committee is the one that is working with Dr. Macdonald. We have a liaison officer in the secretariat merely to see that the timetables are being met, the administrative procedures carried out and that they are generally falling within the terms of reference to ensure that the study is proceeding normally.

Senator Belisle: I shall have to re-read what Dr. Solandt said, because it was my understanding that he felt they were the authority to recommend to the Privy Council.

Dr. Weir: Maybe I am not being clear on this. They have the authority now; they are the ones who recommend on Dr. Macdonald's report, not the secretariat.

Senator Belisle: That was my understanding.

Dr. Weir: That is right.

Senator Belisle: That is your understanding too, is it?

Dr. Weir: Oh yes.

Senator Belisle: You were formed in 1964. What budget were you given, approximately?

Dr. Weir: I think I would have to ask you to let me reply to your question later. As you know, I was not here till 1965. I cannot recall from memory. It was an integral part of the Privy Council office budget. I am not sure that it was all separated out into the Science Secretariat.

Senator Belisle: Perhaps I might be permitted to make this comment. After the answer given to Senator Grosart a while ago on this hair-splitting policy I can understand your prudence. Let me ask a second question. What is the estimated budget for 1967-68? You said a while ago there were 27 on the staff and you had approximately 30 positions on the secretariat.

Dr. Weir: This is the approved establishment.

Senator Belisle: Do you have a figure in mind of what you requested?

Dr. Weir: Yes. We have an estimate, but I think, Mr. Chairman, I should take this question under advisement. I have to stress that I am in the Privy Council office as a public servant.

Senator Belisle: Is it confidential?

The Acting Chairman: Can I put it a little differently? The estimates that are presented are presented in detail and available to members of this committee and to the Senate, and in due course to the public. The only question is as to whether there is a division within the Privy Council budget of funds which are earmarked for the specific purposes, which is published as such.

Senator McCutcheon: And a very important question it is.

Dr. Weir: There is an item in the Privy Council office, under the budget for the Science Secretariat and for the Science Council. This, may I say, is in the process of evolution, as to when the activities begin.

Senator Belisle: Beginning in 1966-67, surely you can answer this question, if it is public information. If you cannot answer this question, what is the advantage of your present position? This is simply a mathematical question. Probably I could go and get the Estimates and get it, but surely you should be familiar with this. As chairman of a university, I can tell you how much was spent last year.

Dr. Weir: You are asking for ...?

Senator Belisle: 1966-67?

Dr. Weir: 1967-68.

Senator Pouliot: $100 million.

Dr. Weir: It was approximately $450,000—between $450,000 and $500,000.

Senator Belisle: Thank you.

Dr. Weir: That is in last year, not the Estimates for this year, which is what I thought you were asking for.

The Acting Chairman: Not this year.

Dr. Weir: Yes.

The Acting Chairman: Senator Pouliot has been very patient and we appreciate that, sir. You told me you had two questions you would like to put.

Senator Pouliot: Thank you, Mr. Chairman, but I do not have to take the place of anyone.

The Acting Chairman: That is quite all right.

Senator Pouliot: Now, sir, tell us, tell the committee, what is the total number of your staff?

Dr. Weir: The total number of staff?

Senator Pouliot: Your personnel. You mentioned 200?

The Acting Chairman: Those were contract.

Dr. Weir: Those were contract.

The Acting Chairman: Are they Science Council or Science Secretariat?

Dr. Weir: Some of the consultants are of the Science Council staff, or their expenses...

The Acting Chairman: The question Senator Pouliot is putting is a clear one, a clear one—a direct one. How many full-time staff, as it were, who are part of your organization, the Secretariat? And the second part was, how many are attached for special purposes?

Dr. Weir: We have an approved establishment of 27 professionals and 30 sub-professionals. We have on staff 20 professionals and 13 sub-professionals.

The Acting Chairman: That is, 40 in all.

Senator Pouliot: How many stenographers, besides that? I want the total number of your personnel, the personnel of the Science Secretariat of the Privy Council.

Dr. Weir: In the sub-professional staff I include stenographers.

Senator Pouliot: Oh no, professional and non-professional. The total number of personnel.

The Acting Chairman: 40?

Dr. Weir: Both totalled together?

Senator Pouliot: All together?

Dr. Weir: 40.

Senator Pouliot: Well, now, I found when the Estimates were produced, that in 1966-67 it was $6,551,767. In 1967-68, the first figure was $8,893,867, an increase of $2,342,100. And it does not include the supplementaries. With the supplementaries it was, for 1967-68 $11,621,967, or an increase of $5,070,200.

In 1968-69, in the Main Estimates, without any supplementaries, it is already $7,769,467, or a decrease of $3,852,500, but that decrease will be at least evened when the supplementaries come in later in the fiscal year.

Now, if we take this in rough figures, we have for 1966-67 $6,500,000 and in the following year it is $11,600,000. The provisions now are $7,700,000. So it is over $25 million for three years.

The Acting Chairman: Are those amounts of money spent by the Secretariat or by the Science Council as well?

Dr. Weir: I wondered what is the source of the information?

Senator Pouliot: It is the estimates for the current year.

The Acting Chairman: For what year, senator?

Senator Pouliot: 1968-69.

The Acting Chairman: For what purposes?

Senator Pouliot: For the Privy Council.

The Acting Chairman: That is the Privy Council.

Senator Pouliot: It includes naturally the salary of the President of the Privy Council, but this does not amount to much. I have the figures here, Privy Council and General Administration. It is put in that manner, and it is very strangely arranged, because there is nothing specific for the Secretariat. It is at page 410 of the Estimates for 1968-69. There is the clerk of the Privy Council. I leave aside that, but here is:

1. Director, Science Secretariat ($26,500)
1. Special Scientific Adviser ($24,840)
3. Principal Scientific Adviser ($21,000-$25,250)

There is one director and one special scientific adviser, and there are three principal scientific advisers. Then there are four senior officers 3, which is an increase of two:

4. Senior Officer 3 ($20,500-$25,750)
4. Senior Officer 2 ($18,500-$23,500)
1. Senior Officer 1 ($16,500-$21,250)
19. ($18,000-$21,000)

And so on. All that is on the page. Now sir, I will ask a question. All that costs lots of money and I would like to know what has been your achievements since the establishment of your Secretariat?

Dr. Weir: Mr. Chairman, if I understand the senator's reference, he is talking about the whole Privy Council office. The staff of the Secretariat is part of this but only a very small part.

The Acting Chairman: You have no separate budget set out in the Estimates?

Dr. Weir: No. The only budget that is set out separately in the Estimates is the budget for the Science Council, which in 1967-68 is $190,000, shown at page 395 of the Estimates for 1967-68.

Senator McCutcheon: There are three positions spelled out in detail, relating to the Science Secretariat, at page 392 of the 1967-68 Estimates. There is the director, Science Secretariat, the special scientific adviser, and the principal scientific adviser, of which there are three of the latter. But you cannot go further down and say they belong to the Science Secretariat.

Senator Pouliot: We do not know.

Senator McCutcheon: We do not know.

Dr. Weir: This is included in the total Privy Council budget.

Senator McCutcheon: That is right. There are five of your officers who are delineated here, in my submission. But whether it is senior officers belonging to you or your secretariat or some other secretariat in the Privy Council or whether they are general officers of the Privy Council there is no way of telling.

Dr. Weir: This is not separated out, no.

Senator Pouliot: Well, I think I can help you, and I have merely taken my information from the looseleaf telephone book. It is very interesting. There is the Privy Council Secretariat and there are the members of the Science Secretariat, East Block. The Director is Dr. J. R. Weir. The Secretariat is E. R. Wheaton. The principal Science Advisor is Dr. J. R. Whitehead. The Secretary is Mrs. Johnston. They are too numerous to be together in the East Block. So part of the staff is at 110 Argyle. These are the advisers: D. Cass-Beggs, H. Flynn, S. A. Forman, D. W. Henderson, E. O. Hughes, R. W. Jackson, D. E. L. Maasland, A. H. Macpherson, G. T. McColm, E. G. Munroe and J. C. Lachaine.

Besides that they have a task force. It was the first time I had heard about the task force, because I had not looked into the telephone directory before, but it must be under you, Dr. Weir.

Dr. Weir: This is a task force that was requested?

Senator Pouliot: Yes. There is no room for them at 110 Argyle. They have to go to 150 Kent, the Skyline. The Chairman is Dean H. D. Woods, and the members are Dean A. W. R. Carrothers, Professor J. H. G. Crispo...

The Acting Chairman: Those, if you will excuse me, Senator Pouliot, are the task force in terms of labour relations.

Senator Pouliot: I know.

The Acting Chairman: They have nothing to do with Dr. Weir.

Senator Pouliot: You have nothing to do with them?

Dr. Weir: No. We have nothing to do with that task force.

Senator Pouliot: Thank you. Speaking of your relations with the Science Council, the Science Council was established only last year. Is that true?

Senator McCutcheon: It was established in 1966.

The Acting Chairman: In the autumn of 1966, I believe it was, sir.

Senator Pouliot: 1966.

The Acting Chairman: The bill went through the Senate at that time.

Senator Pouliot: When was it created? In 66 or 67?

Dr. Weir: 1966.

Senator Pouliot: But from 1964 until 1966 you could have had nothing to do with the Science Council.

Dr. Weir: That is right. It did not exist.

Senator Pouliot: It was non-existent. Were you under the President of the Privy Council or under the Prime Minister?

Dr. Weir: We were in the Privy Council office.

Senator Pouliot: Yes. Who was your minister? Was it the President of the Privy Concil or the Prime Minister?

Dr. Weir: The Prime Minister, sir.

Senator Pouliot: You had nothing to do with the President of the Privy Council?

Dr. Weir: Not in effect, no.

Senator Pouliot: You were reporting to the Prime Minister.

Senator McCutcheon: Let us hope not.

Senator Pouliot: Well, I have another question to ask you, and I will end it there. How many of your staff wrote speeches for the Prime Minister?

Dr. Weir: None, sir. We did not do that.

Senator Pouliot: Well, I know that some did, either on the Privy Council side or on the other side.

The Acting Chairman: Yes, sir, but you have to distinguish.

Senator Pouliot: I will not insist on it.

The Acting Chairman: You have to distinguish between these unfortunate scientists who have a limited responsibility, sir, and other members of the Privy Council.

Senator Pouliot: Well I have an engagement for luncheon. I am very sorry to leave, but I thank you, Dr. Weir, and you, Mr. Chairman, and I thank my honourable colleagues. I will leave it at that.

Senator Desruisseaux: Mr. Chairman, Dr. Weir, thank you for all this information you have revealed at one time or another. Part of my question was answered in the first part of Senator Belisle's question, but, for the record, I think it should be known here that the establishment of the Scientific Secretariat was a furtherance of the recommendations of the Royal Commission on Government Organization that took place in January of 1963. In this respect I would like to mention for the record that:

> In respect of research and development policy, four recommendations were made, that:
>
> (i) the proposed President of the Treasury Board be designated as the Minister responsible for the scientific policy of the country and the co-ordination of existing activities in the field of research and development;
>
> (ii) a Scientific Secretariat be established for the Cabinet under an officer to be known as the Scientific Secretary, reporting to the proposed President of the Treasury Board;
>
> (iii) an Executive Council be established, with membership drawn from the scientific disciplines, the universities, industry and the community at large, to review and submit independent advice with respect to national scientific policy;
>
> (iv) the Scientific Secretary act as secretary and the Scientific Secretariat serve as the secretariat for the Executive Council.

I would add this comment that this is an O.E.C.D. publication entitled *Training of and Demand for High Level Scientific and Technical Personnel in Canada* that is part of the reviews of national policies for education.

Immediately after what I just read before is the following remark:

> The Royal Commission was particularly concerned with the problems of co-ordination (of which it generally found a lack) of the policies and programmes of the various Federal agencies.

This is only for the record for reference, if need be. But I would like to put a secondary question, one of secondary importance considering what has been discussed here, Mr. Chairman. I would like to know whether you had anything to do with the study concerning satellites, Dr. Weir?

Dr. Weir: Whether the secretariat did?

Senator Desruisseaux: Yes. Were they called upon or did they on their own do studies about the satelite position of Canada? If so, did they make recommendations?

Dr. Weir: Well, might I refer this to Dr. Jackson?

Dr. R. W. Jackson, Adviser, Science Secretariat: To recapitulate the history of the studies in space, they were initiated within the secretariat, before this Science Council was formed in recent months, to deal with problems which were very apparent at that time—problems of policy for the Government. When the Science Council was formed, the study already under way under a group of consultants was accepted or taken over by the Science Council as one of its authorized studies, and the report of that study, when it was completed,—and it has popularly become known as the Chapman Report—was submitted to the Science Council and shortly thereafter was published. The Science Council made its assessment of that report and prepared a report of its own. I think the title was *Upper Atmosphere and space Programs in Canada.* This dealt with space policies for Canada and was in its turn published. It made certain recommendations including that attention be given to the whole question of communications by space satellites as one high priority and, for example, a recommendation that a space agency should be formed to co-ordinate all these fields of activity.

The next stage in the process was that the secretariat was asked to set up a task force to study what the Government action should be regarding communications satellites. This of course involved many confidential issues, legal issues and issues of international relations, and therefore was conducted as a task force study within the, if you like, Privy Council Office function of the secretariat. Now, that task force has completed the first part of its work on the satellite communications study.

Senator Desruisseaux: If I may interrupt at this juncture, were you helped from outside in preparing these surveys and recommendations? By that I mean were you getting help from industry?

Dr. Jackson: Assisting as consultants in the Chapman study group was one person from industry, and one each from the University of Toronto and the University of Western Ontario. Then there was Dr. Chapman who was seconded from D.R.B. That was on the first part. On the Privy Council task force there were also external consultants engaged, I believe. They were not all from within government. The results of that first phase, I believe, are being prepared as a White Paper.

Dr. Weir: It is not correct to say that there were consultants from outside government. They were from within government departments or agencies.

Senator Desruisseaux: Intradepartmental.

Dr. Weir: And they are now completing this second stage.

Senator Desruisseaux: There were no outside industrial consultants on these decisions, and these decisions are now about to be made.

Dr. Weir: The actual composition, as I recall it, was as I have stated, but there were submissions from outside. It was not limited just to submissions from government departments and agencies; there was a large number of submissions from many areas outside.

The Acting Chairman: Just an incidental question relating to the same matter. I understand that there has been or there is likely to be in the near future a statement or announcement in respect of action in this field of communications satellites by Canada. Has that come out yet?

Dr. Weir: Not to my knowledge.

The Acting Chairman: It has not beer made public yet?

Dr. Weir: Not to my knowledge.

Senator Grosart: In the Chapman report at page 233 there is a reference to the HARP orbital program. Now this report was published in February 1967 as study No. 1. Is there any relationship between the statements —I won't call them recommendations—in the Chapman report and the later political decisions regarding HARP? Let me put it this way, would you care to relate the two?

Dr. Weir: I think, if I might answer your question in this way, I can only say that that information was available to the Government in the form of that report plus the Science Council's report when they made their decisions.

Senator Aird: I would like to ask a general question concerning the word "inventory". This concerns me as I find it rather an anomalous word to be used in the scientific field. I can understand how one would take an inventory of this room and the furniture that is here today and is likely to be here tomorrow and next week. But science is such a changing field it seems to me that part of the problem is what I would term a clearing house problem which goes to the fundamental problem we are trying to consider here which is a study of priorities. I would be concerned that when you have an inventory report as of a certain date relating to a certain subject, that virtually as of that date it is obsolete. It is the going forward process which would concern me, and my question is: Is your secretariat proceeding with studies as to communications and as to clearing and as to—perhaps this is the wrong word—a control centre or in effect a distribution centre from where the decisions have been made rather than looking historically to inventory?

Dr. Weir: I think perhaps the use of the word "inventory" as identifying articles is, in this sense, not really appropriate. These were studies by consultants, specialists and groups to outline the magnitude of the work. This is pretty well contained in the terms of reference of our studies. The first of these is agricultural research, and I am certain Senator Hays has a special interest in this. They are as follows—Current status of agricultural research: To assemble a composite picture of the organization for agricultural research within and among the agencies concerned; to survey the distribution of effort among these agencies and among the various aspects of agricultural research; to assemble a composite picture of the organization for the education and training of scientists and supporting staff for agricultural research; to consider and compare the organization and management of agricultural research in Canada and other countries.

Then on appraisal of the adequacy of agricultural research: To evaluate the costs and benefits of agricultural research to Canada; to appraise the adequacy of the current research effort to meet Canada's present needs; to determine the problem areas and to appraise the appropriateness of the current distribution of effort among them; to appraise the pertinence and quality of research for meeting the recognized problems of Canadian agriculture; to appraise the adequacy of the organizational and management systems for meeting these problems; to appraise the adequacy of current methods for ensuring the integration and utilization of research by the agricultural industry; to evaluate the degree to which our research capability, research personnel, and total financial resources are being used effectively to support the education and training of agricultural scientists, and the adequacy of this education with reference to agricultural research.

Future development of agricultural research: to project the major trends and needs for agricultural research over the next 5 and 10 years; to consider criteria and guidelines for setting priorities to meet these needs; to recommend on means for integrating socio-economic research with the planning, conduct and appraisal of production research; to recommend on the organizational structure, management system, and distribution of effort, best suited to meet the needs, and for ensuring effective coordination with other areas of research impinging on or affected by agriculture.

Then, in general: to study or appraise any other matter that in the opinion of the study group is pertinent to the present or future state of agricultural research in Canada.

"Inventory," in this respect, is used too, so that principally this is to give the present state of the situation that does exist, in a broad context.

Senator Aird: It gives you your starting place. What I am really concerned about is the emphasis, that it should be on the end rather than on the beginning. My question is: Are you satisfied that this process is being effected?

Dr. Weir: Well, we are never satisfied because, at best, we are going to have many areas that do not have information adequately available, and we are going to have many different levels of accuracy. Our plan was to try to cover the fields of the Natural Sciences in this kind of up-dating study, to know what we are doing in Canada in these fields in about a three-year period. Of course, I agree with you that the day after this report comes in, even before it comes in, even before it is written, things are changing. You have to accept it as an on-going process, and the best information we can get, before looking at the total picture, is to look at all these areas of the Natural Sciences.

Senator Aird: This relates to the previous questioning of Senator McCutcheon and myself. Any delay in these reports, any delay in so-called inventory or in conclusion, I think, derogates from your own final position —well, I suppose you never have a "final" position, but your decisive position; and I would like to have as many things flowing in as coincidentally and as quickly as possible.

Dr. Weir: So would we. We are trying to keep these things on schedule. However, a number of things start to happen. I am concerned about the continued up-dating of this kind of information. If the Secretariat is the agency that must continue this up-dating, then it is quite a large operational stage—something I personally do not anticipate—but, as part of the planning, I think we should see that somewhere in the government such a background of information is as much up-dated as possible.

Senator Aird: If you do not do it, who else is going to do it?

Dr. Weir: Well, I would suggest this has to be looked at to see if there is a more appropriate place. If this is the kind of operation the Secretariat is in, then we are more than one person, an advisor and a couple of assistants.

There is another thing that concerns us. Once this kind of information comes in, in general, then I think we have to start—and we are starting now—to utilize this in studies directed towards future effort, priorities, changes and planning based on this. This was our original concern, before we really did any of the other. We had to have something like this, to know what we were doing in Science in Canada, as close as we could come to it.

Senator Hays: Dr. Weir, I suppose your particular Secretariat was born as a result of the report that Dr. MacKenzie had written to the Prime Minister in 1964; and your terms of reference are probably much the same.

I notice on page 37 of the report the terms of reference are spelled out, and are very similar to those of your counterpart in the United States advising the President on scientific policy and that sort of thing. Am I correct in this?

Dr. Weir: With the appropriate differences of government organization, yes.

Senator Hays: But, generally speaking, the broad general principle is the same?

Dr. Weir: Yes.

Senator Hays: This is a sort of copy of the one also advising the President of the United States—the same as you are supposed to advise the Prime Minister?

Dr. Weir: In very broad terms, yes; but beyond that there are major constitutional differences.

Senator Hays: I realize that.

On page 37 of the report, paragraph 3 states:

> To achieve more effective utilization of the scientific and technological resources and facilities of Federal agencies, including the elimination of unnecessary duplication;

I do not know how much power your Secretariat has to dictate to, or just advise, I suppose, the Privy Council, when there are duplications in your studies insofar as these programs are concerned.

If I might just have a minute, Mr. Chairman, I will give you three examples in agriculture that seem to me to involve a great deal of waste, and they are still being carried on for the most part, and represent, over 10 or 15 years, maybe millions.

In agriculture, as you know, we spend about $30 million on research. This is the budget, and I think it has reached a sum now of maybe $33 million. We had a program—and this related to livestock—for the correction of bloat in animals that is caused by the use of alfalfa. In 1963 Russia was doing a great deal of work on this program; they were doing a great deal of work on it in New Zealand and in the United States; and in four different locations in Canada we were doing the same sort of work—and this has been going on for many, many years. In feeding alfalfa to an animal with four stomachs, like a cow, which is just like giving a man whiskey, if you give him enough he will get drunk. This has never changed. If you give a cow enough alfalfa she bloats with gas, and she dies. This program has been going on for years and years. To me this is a sort of useless exercise, and there does not seem to be an answer to it.

Another project dealt with the use of buffalo to replace domestic animals. This has been going on for 35 years or more. We have been trying to make the buffalo as good as a domestic animal, or a British animal, which is just impossible. Another one is that of trying to select animals through chromosomes and genes.

I suppose you have somebody in the Secretariat who is familiar with these research programs. Russia was engaged in the breeding program for a long, long time, and then they decided they would wrap it up. The United States did the same thing. Yet, we are still going on with it, and I do not know what the cost is. I suppose that in 15 years we have spent perhaps $16 million.

I happened to be the minister at the time, and I looked at these programs. I was concerned about them for many years. I thought: "Why should we do this? Why not eliminate them?". We finally got the buffalo one wrapped up. It is now tucked away, but we can continue it later if necessary. The study of the grass feeding of animals is still going on, and so is the breeding study. No doubt the person in charge looked at the politician and said to himself: "Well, he will get defeated, and I can go on with it in any event. You are a bit different, being a civil servant, but how are you handling these programs? Are you getting anywhere with them in respect of Dr. Mackenzie's recommendation to the Privy Council about eliminating unnecessary duplication?

Dr. Weir: Mr. Chairman, again I probably will not be able to give Senator Hays a satisfactory answer, but I would like to point out one or two things. First of all, we have in the Science Secretariat no regulatory power. We have no control over operational budgets, nor do we have any authority to change any programs anywhere in the Government. Our role is that of an adviser. We are in an advisory capacity.

I would hope that out of our study on agricultural research, as in other areas of research, might come recommendations for administrative procedures to check the kinds of things you mention. These, I think, are, to some extent qualitative judgments as to when you cease an experiment, and what is its value, in the first place, going to be. I think in the Secretariat all we can possibly do is to determine whether this is all divided internally within a department or agency, or whether there is an outside body of expertise that might look at the program, and draw attention to it, but the responsibility for the program itself, I am sure you will agree, rests with the minister under whom the work is being done. It has to.

Senator Hays: You feel, then, that this body that was set up to examine all these things—is your advice taken in so far as these programs are concerned, or have you got that power alone in your studies of the various programs?

Dr. Weir: Obviously, we have not. This has not come into it, but somebody mentioned the changing role of the Secretariat, and it has changed a great deal really from Dr. Mackenzie's recommendation, even by evolutionary circumstances. But, if it ever got to the point of looking at specific experiments I would say its role has changed almost completely. Again, I come back and say that I think this is the responsibility of the department or agency concerned, to decide whether its program is evaluated as to quality and as to duplication.

Senator Hays: Of course, one of your terms of reference is:

> To identify research needs, including areas of research requiring additional emphasis.

It deals also, in your opinion, with the elimination of some of the programs that are obsolete?

Dr. Weir: I think, senator, we have got to look at this and understand at what detailed level of recommendation we are looking at. In the first place, there is science as a very broad subject. In the natural sciences we have the physical sciences and the life sciences. The life sciences we have broken down into various disciplines and various usages. Broad program areas may develop as a result of recommendations. I think these are the areas that we, in the Secretariat, can really look at. If we ever got into the role of evaluating projects in agriculture we would of necessity have to duplicate the work of the Department of Agriculture. We would have to go to a number of agricultural people because, I suggest, sir, in order to determine whether these are duplicated projects, or whether they are projects worthy of being carried on, we would have to make a subjective evaluation within the field of the operational scientist.

The Acting Chairman: Could I put this in a particular way? If Senator Hays, as member of the Privy Council, were to feel as he apparently does about three pieces of research, can he go to the Science Secretariat and say: "Am I right, or am I crazy?" and would you be responsible for getting for the Privy Council in a confidential way the answers to his problem?

Dr. Weir: Yes, I think we would have to do that.

The Acting Chairman: That is the question you were really asking, is it not?

Senator Hays: Yes.

Senator Grosart: Mr. Chairman, I have a supplementary question. I am rather surprised at the answer Dr. Weir gave because as I read the terms of reference it seems that the Science Secretariat is given authority to do things that should be done by the Minister.

Perhaps I could quote them rather quickly, Dr. Weir. You are to assemble a composite picture of the organization for agricultural research within and among the agencies concerned; you are to survey the distribution of effort; you are to consider and compare our organization with those of other countries; you are to evaluate the costs and benefits of agricultural research to Canada; you are to appraise the adequacy of the current research effort; you are to appraise the adequacy of the organizational and management systems; you are to consider criteria and guidelines for setting priorities; and you are to recommend on the distribution of effort. Now, this seems to me to be the very thing that Senator Hays is suggesting you should be doing, and yet I understood you to say that this is not what you are doing.

Dr. Weir: I accept those as terms of reference, but in my thinking this is different from saying whether a continued broad program for improvement is a good or bad program.

Senator Grosart: Why not? This seems to be inherent in these terms of reference. You are asked to evaluate the benefits, and to survey the distribution of effort; you are asked to approve the adequacy of these things; you are asked to set priorities, or to recommend priorities; and you are asked to consider the duplication of effort. Surely, these would take in the buffalo and the alfalfa feeding programs? I am saying that in my understanding of this I do not see how you can exclude the buffalo program, or any of the other programs that Senator Hays mentioned.

The Acting Chairman: If you were asked for advice on this you would have to have the necessary members get that advice and submit it to the person in the Privy Council who asked for it?

Dr. Weir: If I were asked for that advice I would have to consult the Department of Agriculture.

The Acting Chairman: Yes, in order to see whether they were doing their research?

Senator Hays: The great problem, Dr. Weir, is that here you have 30 sections of land that have been purchased or leased, and you have built up a big staff. It takes a lot of people to take care of these animals, and they are people who are vitally interested in these problems. For example, where they have a calf every other year we hope they will have two a year, something like that. These things are quite obvious. We would still have 5,000 buffalo, we would not have traded them for 5,000 domestic cattle. There is this great duplication which you mentioned all over the world.

The Acting Chairman: I think the point is that you made reference to people who seem to have a vested interest in the problem on which you want advise.

Dr. Weir: I agree with this, and this is why I previously mentioned the need for a planning operation for research which is not in the operating department. If I may say so, in my opinion the point you raise is the detailed level at which you expect the Science Secretariat to comment. If you extend this to the whole realm of research in the physical sciences, life sciences and health sciences it will demand many expertise, evaluation and in order to answer this question I suggest that we would have to know something about the buffalo and so on.

Senator Hays: I realize that, but it involves $20 million in ten years, which is a dollar per capita in Canada, quite a bit of money.

Senator Belisle: In view of what Dr. Weir said about the four or five studies in progress on which reports will be prepared some time this fall, give or take some months, I feel it is imperative that we have these reports before we finalize our report. As you have expressed willingness in this respect, would it be possible for us to be given the first phase report? Many of these reports come in several phases. Would that be possible?

I might add that I would not want you to go away with the feeling that I at least was not sympathetic to your committee. On the contrary. However, I think you should bear in mind the magnitude of our work, and unless we ask questions to find out who is who and where we go we cannot complete our task. We can only do this through questions.

Dr. Weir: Perhaps I might make this comment. These reports will be Science Council reports, and with the permission of the chairman of the Science Council for their release I am sure they could be made available to you. Our background reports are available as soon as they are published. This is why I said at the beginning that I hope we have an opportunity later on in your discussions, as we move along in this phase of the work, to discuss with you or submit to you our most advanced thinking, because it is changing very rapidly in a very short period of time.

Senator Grosart: I should like to pursue this apparently anomalous position of the secretariat within the structure of the organization of government. I should like to qualify my remarks by saying first that I agree with Senator McCutcheon that something which appears in the government structure to be anomalous may well work out very well practically. Secondly, I follow Senator Belilse by saying that we may have appeared in our questioning to have been critical of the secretariat, but I can assure you that I am not in any way concerned about the size of the secretariat or the money you are spending, because all the evidence I have is that it is very well spent and that you have an excellent administration of your secretariat.

However, we discussed your budget, and that brings up a question which has been before the Standing Committee on Finance of the Senate which always worries us. We have been told over and over again that the "new look" in the Estimates will be to have project budgets, that we will have a vote for every project. Here within the Privy Council is a project if ever there was one, the Science Secretariat, yet when we look at the cash requirement for this project it is impossible to find it. I respectfully suggest to you that you might speak to your colleagues in the Privy Council and suggest to them that you have a vote so that we do not have a senator doing scientific research via the Government telephone directory, which is what we had this morning. I am not critical of the senator. Where else would he go except directly to your secretariat, who would have given him the information I am quite sure. This is a problem which comes up over and over again, and I suggest that it would make much more sense and obviate some of these apparent suspicions if there was a vote which said, "This is what the Science Secretariat costs."

I am not clear yet about your responsibility. In other words, who is your boss? The royal commission suggested that you report to Parliament through the President of the Treasury Board. Has that been done?

Dr. Weir: No.

Senator Grosart: That has not been accepted?

Dr. Weir: No.

Senator Grosart: Then do you report through the president of your own council, the President of the Privy Council?

Dr. Weir: No. I think we should distinguish between the Privy Council and the Privy Council office.

Senator Grosart: It is a pretty fine distinction but I will not pursue that. Then in effect you report through the President of the Executive Council, the Prime Minister.

Dr. Weir: That is right.

Senator Grosart: Is there a danger that in making a recommendation or doing work for, say, the Science Council, the direction of your work might be influenced by your political responsibility to the Privy Council, which after all is a political body? Is it not possible that we would wind up with a situation where what appears to be a recommendation of the Science Council actually reflects the current political thinking of government? I say this because, as we all know, and as has been the experience of all of us, anybody who collects, analyzes and presents the data in effect makes the decisions. Is there any danger in this, or do you find yourself in any anomalous position here? This is not in any way a critical question.

Dr. Weir: It is a question that does concern me.

Senator Grosart: That is enough of an answer for me.

Dr. Weir: I think I should qualify it by saying this. After all, studies for the Science Council are done by professional people, many of whom are consultants whom we take on for varying periods of time. Their reports to us are their own reports unedited by the Science Secretariat itself, and they are published with disclaimers that they do not reflect the views of the Science Secretariat. The Science Council can use the work we do. If it is not satisfied with the work we are doing for it, it can engage other bodies to do similar kinds of work. If it feels the direction of our work is being influenced by political considerations, it could say "This is not good enough for us, you cannot be our secretariat, we have to get another study of this done."

To come back to the other point, if the Science Council approves a study of a particular subject, approves the terms of reference, approves the professional people who do the study, and follows it through its study and development, and accepts the report and commissions their report to be written, whether it is our people or somebody outside that does it, they are making the decisions and accepting this as theirs. I have got to say this. People are human. What goes into reports is the thinking of people. You could have a study group consisting of a major group of university people. I would suggest that here is a point where there could be in general terms, in universities, a political line of thinking which might influence a report equally as well.

Senator Grosart: I would say this, finally, that I was concerned more with the possibility of unconscious bias, and not because I felt in any doubt about the level of intellectual integrity of the kind of people who are on the Science Council or on the Science Secretariat.

Senator Belisle: In all these studies we have made, we have never given any thought to or spoken about the provincial governments' research setups. Are you related in any way with them, on occasion?

Dr. Weir: Our studies on research on physics in Canada, on chemistry in Canada, on agriculture in Canada, on engineering in Canada, whether done in government or in industry or in provincial research councils or in universities or in private organizations is done to get a picture of research in Canada, not just research in one sector, but in all sectors. In the case of engineering, we take in engineering in universities, in industry and in government.

I am sure you recognize that there will be overlapping in the results coming out of such studies. Physics will be inclined to overlap with outer space studies, chemistry may overlap with engineering. We have been holding meetings of our study group leaders to try to develop a pattern that will sort out or prevent this duplication. Of course, the university studies will overlap with them all.

We have been faced with another problem. We have been preparing to deal with a large portion of our work by questionnaires, and this has been very disturbing to the community. We have to try not to disturb the scientific community in universities.

We have a problem in industry, in the release of information.

All these are management problems, interpretation problems, which have to be considered and which condition the use of this information. We are going through this for the first time as well.

I suspect that out of our first round of studies, not only there may be a change of emphasis but a different approach to getting this kind of information, when we identify the weaknesses in what we are doing.

We are trying to keep everything in touch, through our liaison officers in the Secretariat, and we are holding meetings also of our study heads.

To me, this is part of our managerial work, to keep in touch with the various committees of the Council. It is a reasonably complex kind of arrangement.

The Acting Chairman: Honourable senators, gentlemen: Before we adjourn, I would like to say that we have been a rather tough committee this morning. I do not apologize for that, as it is evidence that we take things seriously. We want to get as much information as possible and get to the roots of this matter. We are most grateful to you and your colleagues for coming here and submitting yourselves to this kind of cross-examination. Some of us are lawyers and are accustomed to this kind of exercise, without too much sympathy with the witnesses.

Almost certainly, our studies, like your studies, will take considerable time to complete. I feel it is almost certain that we will want you or some of your colleagues to come back and talk to us again, as we get further along our interviews and our studies. I have a number of questions I would have liked to have asked, if there had been time; and I am sure this is true of Senator Kinnear, who has been a very patient member of our committee.

Senator Kinnear: I have been very quiet.

The Acting Chairman: I said "patient".

Senator Kinnear: Other senators have asked the questions I had in mind, especially Senator Aird, who is near me.

The Acting Chairman: We are grateful to you and thank you very much, gentlemen The committee is adjourned until 3.30 p.m. today.

The committee adjourned.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Thursday, March 21, 1968

The Special Committee on Science Policy met this day at 3.30 p.m.

Senator Norman A. MacKenzie (*Acting Chairman*) in the Chair.

The Acting Chairman: Honourable senators, if you will come to order we will get on with the afternoon session of the committee. As you know, we have with us this afternoon representatives of the Medical Research Council of Canada and, on your behalf, I welcome them here.

I am going to ask Dr. Brown if he will be good enough to introduce his colleagues, and then perhaps lead off the proceedings by giving us some information and views about the work of the Council.

Before you commence, Dr. Brown, I should mention that there are one or two members of the committee who have to leave early. Senator Sullivan, in particular, has suggested that he may like to intervene during your statement with an appropriate question. I am sure you will not object to this. The same applies to other senators who have to leave in order to catch a plane or other conveyance.

Perhaps you would now introduce your colleagues, Dr. Brown, and carry on from there.

Dr. G. Malcolm Brown, Chairman, Medical Research Council: Thank you, Mr. Chairman. On my right is Dr. J. A. McCarter, Director of the Cancer Research Laboratory and Professor of Biochemistry at the University of Western Ontario. Dr. McCarter has been a member of the Medical Research Council for the past six years.

On Dr. McCarter's right is Dr. J. Maurice LeClair, who is Vice-Dean of Medicine and Professor of Medicine at the University of Sherbrooke; he is presently not only a member of Council but a member of the Executive.

Mr. Chairman, the first thing that we would like to say concerns our gratification over the establishment of the Senate Committee on Science Policy. We have enthusiastically and unanimously welcomed the establishment of this committee because we think that out of it can come nothing but good. We want to assure you, sir, that there will be all possible collaboration on our part in your work, because we think it is important, and we are anxious to make any contribution we can.

(*Translation*)

Dr. J. Maurice LeClair, Vice-Dean of the Faculty of Medicine and Professor of Medicine, University of Sherbrooke: Honourable senators, allow me to repeat in French the words just spoken by the Chairman, Mr. Brown, to express our gratification over the establishment of this Senate Committee. You may indeed rely on our full co-operation and be assured that we shall do everything we can to make your task a fruitful and pleasurable one.

[*English*]

Dr. Brown: Some preliminary material has been made available to the committee, but I might just sketch out a few points.

The Medical Research Council was established in 1960 by a cabinet directive to the National Research Council. It had been preceded by another committee under the name of the Division of Medical Research of the National Research Council, and before that again by a so-called Associate Committee which goes back to 1938 and the days of General McNaughton and Sir Frederick Banting. The Medical Research Council was established as a virtually autonomous body; it is independent in its policy but it works within the administrative framework of the National Research Council. I may say that the council is anxious now, and hopes to proceed as quickly as possible, to obtain legislation so that the Medical Research Council is established as a completely independent body, and the umbilical cord of the National Research Council, which has been so helpful over the years, finally cut perhaps.

During the years since 1960 especially, the responsibilities of Council have been very much increased. It was not so long ago that most of its interests lay in the area of the basic sciences of anatomy, physiology, through to pathology, and there was not perhaps the same interest in clinical research and the applied research side of medicine. That has changed now; the entire spectrum of medical research from its most basic aspects through to what happens at the bedside is now the interest and responsibility of the Medical Research Council. Its budget, of course, has grown at the same time. In 1960 the budget was $2.3 million, and the budget for 1968-69 is a shade under $27 million.

In this time it has become the main arm of the federal Government in the support of medical research. It has become the main channel through which the federal Government transfers money from itself to researchers in universities and their associated hospitals. In the year 1968-69 it will be responsible for about 75 per cent of this transfer. As well as being a policy instrument it has responsibilities as a policy making body, within of course the very broad terms of reference that are given to it.

It is the Medical Research Council. What is medical research? Medical research is perhaps all that research which has as its aim the preservation of the health and life of man. It is rather far-reaching. It reaches back to and feeds on chemistry, biology, physics; it has a large part of its main corpus in the basic medical sciences of anatomy, biochemistry, physiology, pathology, and it of course extends through to the bedside disciplines of medicine and surgery. It has inter-faces with many other disciplines along the way. Some of the important ones these days are the inter-face with computer science, the inter-face with engineering which is bio-engineering, with electronics and also with the social sciences. That—in no doubt very loose terms—is what it is.

It is fair to ask, I think, where it is done. In Canada the pattern of its doing is not exactly the same as it is in other countries such as the U.K. or the U.S. In Canada it is done mainly in the medical schools and in the hospitals. There is some, of course, in other parts of the universities, in the faculty of arts and science and in the faculty of engineering, and we give grants-in-aid to some members of these faculties because they are doing work in which we are very much interested. It is also done in government laboratories, although the proportion done in government laboratories in this country is less than in the U.K. It is done in industry. We think specially of the pharmaceutical industry, but I would also like to mention the research and development that is of importance to medical care which is done in the engineering industry and in the area of electronics. It is done in a few research institutes, but we do not have many of these in Canada compared with either of our two closest neighbours, the U.K. and the U.S., or our third, France. One feature of the Canadian scene that should be borne in mind as part of the present situation and also of the future, therefore, is that at the moment the vast body of medical research is carried out in medical schools and in universities and their hospitals.

Now, who does it? Members of faculties, teachers, teacher-scientists, clinicians, teacher-clinicians and clinical scientists; in this present year there are approximately 1,400 investigators, researchers, in charge of projects and directing research in the medical schools. There are about 60 more in the schools of pharmacy and there are a few hundred more in the Government laboratories and in industry. These people have various backgrounds. Many of them, but not all of them by any means have an M.D. degree. Some have the D.D.S. or D.V.M. degree. Many, of course, have a Ph.D. degree, and this group includes both those who do and those who do not have an M.D.

Large numbers of graduate students—not only medical graduates—are doing graduate work. Some are B.A.'s doing work in departments of medical schools, work leading to a doctorate in one of the medical sciences.

Then there is all their technical and ancillary staff. The whole group numbers this year something over 7,000.

What does it all matter? Need we care? It is reasonable to ask that, and I think it is a fair question. Do we as Canadians really need to do medical research? Might it not be that we could live quite happily off the research of others? These are questions that have to be answered. The benefits of medical research, leaving aside for the moment where it is done, are well known to all of us and need not be emphasized unduly here. They are benefits in human happiness; I will not say anything more about that. There are also very large economic returns which are not perhaps emphasized as much as they might be.

One might allude to the economic benefits that have followed from the modern treatment of pneumonia, tuberculosis, poliomyelitis, from the modern treatment of diabetes, the modern treatment of most of the infectious diseases. The savings in economic terms from these advances, to which Canadians have made significant contributions, are very very large.

It is impossible to talk in any precise terms about the cost-benefit ratio when talking about medical research; but I would say that, in comparison with the cost-benefit ratio of other types of research, the economic benefits as well as the other benefits are substantial.

There is a recent example of this, of course. One has heard it said in connection with a recent event in South Africa that this form of modern medical treatment is so expensive that it could never be widely applicable or available. Let us look at it for a moment. Let us say that Dr. Blaiberg's operation cost $50,000. Supposing it did; if it is possible to return Dr. Blaiberg to his dentist's office for five years, the community will have more than recouped the cost of the operation and of a couple of others, too. There are many instances like this.

There remains the question: "Why cannot we have all these benefits without ourselves mounting and paying for a large research operation in Canada?"

The answer really is very simple. It is impossible to import new knowledge and new science and use it, unless you yourself have a good scientist; you must have the ability to receive. You do not have this ability to receive without scientists who are doing research. And without research you will have second-rate doctors, second-rate teachers, and there will be second-rate practitioners. It is as simple as that. It will have been emphasized to you many times already how rapidly scientific knowledge, including medical knowledge, is increasing the world over, and you will have heard, too, of some of the contributions made in Canada.

It is increasing at a tremendous rate. But what counts is the application of new knowledge and if this new knowledge is to be put to the use and benefit of Canadians, we must have highly trained people who can quickly encompass this new knowledge and apply it. We must have trained scientists who not only contribute to new knowledge themselves but who can do what is just as important, who can translate new ideas and new concepts into action.

Forty-eight hours or so ago you heard from a very distinguished scientist about this gap between knowledge and action. It applies in medicine and it is a gap which concerns us. This is one reason why the Medical Research Council is very energetic in extending its interest into the clinical part of the spectrum in medical research. You cannot make this translation without a highly qualified and sophisticated corps of people. This amounts to the proposition, then, that if you are to have a good medical corps there must be good medical science.

There are of course other reasons for a Canadian medical research effort, reasons other than this purely utilitarian one, as some might call it, that I have been talking about for the last few moments. Some of them are general in their application.

Scientific research of course is a cultural activity and there is a drive to engage in it which it is impossible to deny in any civilized community. There is perhaps another reason which I wish to draw to your attention. Medical research is an area in which it would be possible for Canada to make great and prestigious contributions and this without the expenditure of horrendous sums of money because, while it is not cheap, it is not as expensive as some other lines of research. This may be a factor to be taken into account.

I have been talking about the need for research. What research is there? What does Canada's medical research amount to now? First of all, let me say that we have a record with some quite notable features. There is the story of insulin, not only its discovery but all the brilliant chemistry which went into a continuance of it. That is well known. There is endoctinology and the study of hormones and their effects, to which Canadians have made major contributions. There has been cardiac surgery and the contributions of the group in Toronto to cardio-pulmonary research—Dr. Shenstone, Dr. Janes, Dr. Bigelow. These have had their effect all over the world. There have been contributions to neurosurgery, and here one mentions the giant, Dr. Penfield. And, not simply because Senator

Sullivan is in the room, there have been contributions too in the area dealing with otolaryngology, that are well known to all members of the committee.

There are also gaps and weaknesses in the story. While we have points of excellence there are too many areas of insufficiency, and the total effort is too small. It is too small for what?

It is first too small to maintain the proper number of excellent medical schools. Why are we in this situation? There are three chief reasons—shortage of space, shortage of money, shortage of men. The space problem is being remedied and here the federal Government has had a very large effect, a stimulatory effect, because of the Health Resources Fund which, with the matching provincial contributions, will amount to a capital investment of $1 billion over 15 years. Even with this, though, it is quite plain that we will take some time to catch up. Five years from now, for instance, there will still be very large problems with respect to space in many of the universities and medical schools.

Money? The situation has improved in recent years, but there is still some way to go. The men? The men will come when there are both laboratories and money. The men will come when there are opportunities and challenges. With the growth in our medical schools—and they are growing tremendously at the moment, of course, there being 12 fully operative now and four new ones underway—and with the doubling of the operation in Toronto, large numbers of teacher-scientists will be needed in the next five years and in the following five. We will not be able to recruit all of them in this country; there are not enough in the pipe-line to be developed sufficiently to meet our needs. Many of them must be recruited from out of the country; then you are of course recruiting on an international market and must pay the prices of that international market. The real price is the development here in Canada of opportunities which will attract men of international standards.

I should like to spend just a moment on the organizational aspect of the extramural support of university research, in contrast to that in industry, Government laboratories and so on. The present sources of funds are mainly governmental, both federal and provincial. There are also very significant amounts of money coming from voluntary agencies. Let us say right away that we in the Medical Research Council hope that the voluntary agencies will always remain a significant part of the scene, because they make large contributions not only in money but in many other ways as well. We are not the least bit monolithic in our views, and we hope that voluntary agencies will always be strong enough not only to be competitors but to be collaborators in various innovations. There are foreign sources of money, but these in percentage terms are not nearly as large as they used to be; they are now in the order of perhaps $2 million.

There are some features to the Canadian pattern of support which must be borne in mind as one thinks of organization. One is that in our country the investigators' salaries, the salaries of those in charge of research, come almost entirely from the universities and only to a relatively small extent from grants. In the United States, in those schools which have a large research effort, this is not the pattern; many of them have reverse ratios, with more of the professors and scientists being paid from grants coming from outside than being paid from university sources.

In Canada, the capital investment in research buildings does not as a rule reach the focal point through labelled research channels. The money for the buildings, the capital investment for buildings, reaches the university through the same channels as money for other capital investments which universities have to make.

Operating costs, however, are different. The costs that remain after the building is paid for and in operation, and after the scientist has received his salary—the costs for graduate students, technicians, post-doctoral fellows, supplies and equipment, all these operating costs—come almost entirely in this country from extramural sources. This is different from the United Kingdom where about one-third of such costs are paid from university sources. It is nothing like a third in Canada; it is probably much less than 10 per cent.

The federal sources of funds for university-based medical research are the Medical Research Council, the Department of National Health and Welfare, the Defence Research Board, and the D.V.A. The latter three agencies will provide about $5,250,000 this next year. Each agency has its own function. The functions overlap, but this is a cause for co-operation rather than conflict. Of these sources the Medical Research Council is now the largest; it will account for about 75 per cent of federal money going into university medical research during 1968-69. Of this amount of money, roughly $27 million, 70 per cent will be spent in grants-in-aid and twenty-five per cent on personnel support of people in training, and of a number of investigators—we call them Medical Research Council Fellows, Scholars and Associates. There is about 5 per cent for research promotion and development.

You will notice that all the Council's budget is extramural. There are no Medical Research Council laboratories, although the desirability and feasibility of those is being investigated by the Council. One possibility being actively explored is that of drug research institutes being established under the aegis and sponsorship of the Council.

Seventy per cent of the money goes for grants. Money is disbursed on the basis of the excellence of applications submitted and the excellence of the records of accomplishment of the men who submit the applications.

The excellence of applications is decided upon by a man's peers. Grants committees are made up chiefly of university people; there is the occasional one from industry and from Government laboratories but the decisions about quality and merit are made by other scientists, not by staff. They bring to this operation a national standard. Applications are judged, then, not against local standards and are therefore largely freed from local influences; they are judged by a national standard.

We are proud of our grants program; we think it is good. But a proper research program on a national scale requires much more than a good grants program. There must be attention given to the development of research, and this has concerned Council a great deal in the last three years.

A system of development grants has been set up; we call them Negotiated Development Grants, because negotiation and discussion precede the making of one of these awards. We have established a system of Groups; these are groups of two to five investigators entirely supported by Council and working intensively on a given program. The first of these has been established in the University of Montreal.

A system of Associateship support of some career investigators also has this aim of development. The scheme is meant not simply to support a number of good men. It is meant to support a number of good men where they will do the most good in developing research when one looks at it on the national scale.

But there are other functions. It is part of the function of the Council to maintain something of an overview of medical research as a whole in the country. There are also requests for consultation, requests from universities for outside independent assessment, sometimes of an internal situation which they are faced with and sometimes of potential new faculty members that they are thinking of recruiting. There is the assessment of the quality of research, not simply the volume but the quality, of research that is going on; during the last 18 months the Medical Research Council mounted a very large effort to assess on a quantitative as well as a qualitative basis the medical research going on in Canada. There is also the responsibility of exploring and getting on with new problems. In the field of transplantation surgery in which the kidney is the most frequently transplanted organ, as everyone knows now who reads the newspaper headlines the basic problem is the rejection of the new foreign organ by the host body. This rejection process can be diminished with certain drugs but the use of these drugs can have unhappy and unpleasant side effects and there is a limit to their use. There is, however, a new agent on the horizon in the form of an antilymphocyte serum which attacks the white blood cells. This looks fairly promising and if it works it will be a tremendous contribution. While our surgeons know of it, there is not a commercial source of supply in Canada, in the United Kingdom, or in the United States, and to the best of my information it will not be available for the next 12 to 24 months. The Council has studied this and it is now planning to sponsor the production in Canada of this antilymphocyte serum as well as to make arrangements for the clinical use and the clinical trial of this serum. This amounts to arranging for the promotion of this new possibility and, coupled with this, the organizing of an attempt to find out whether it really is effective.

There are, however, many other things that concern us. Other functions, aside from the spending of money, are most important and I will just mention one of them again: that is the necessity of finding ways to facilitate the development of weak areas. I mentioned at the beginning our general area of responsibility, which is medical research, and gave one definition of it. Research in medical schools has been our big concern. During the last few months the support of research in the schools in pharmacy has also been added to our responsibilities, so that save for the dentists, and save for research in public health, preventive medicine and epidemiology and operations, which are the responsibility of the Department of National Health and Welfare the Medical Research Council is charged with general support of research in the health sciences. This makes a functional whole; it makes a piece with largely definable boundaries although there are grey areas, of course; but it also makes a manageable whole.

In our operations we have contact with and need to collaborate with the Canada Council, the National Research Council, the Department of National Health and Welfare, the Department of Agriculture—because there is an overlapping between them and ourselves in our research interests—and also the A.E.C.L. With care and with collaboration and co-operation this is managed.

There is a possibility, of course, of lumping them all together. We would make only one comment at this stage and that is to say that perhaps this would not be suitable because it would result first of all in the necessity for splitting them up again so that they could be made to work.

Now, Mr. Chairman, I would be glad, if it were agreeable to you, to have Dr. McCarter speak to you briefly.

The Acting Chairman: Before that there are two things I had intended to bring to your attention at the outset and I would like to do so now. We are very sorry that the chairman of this committee, Senator Maurice Lamontagne, is ill and could not be with us this afternoon. I know he would like me to express to you his regrets at being absent and his appreciation of your attendance. The other matter I wish to mention is that the Senate is at the present time in session and for that reason we do not have the larger audience of senators, who are not members of the committee, in the wings, as it were.

Before turning the discussion over to Dr. McCarter, I wonder if Senator Sullivan would like to say something at this stage or would you prefer to wait?

Senator Sullivan: No, I think Dr. Brown wants one of his colleagues to speak and I think it will be better for me to wait until he is through. I am sure I cannot be critical at all.

Dr. J. A. McCarter, Director, Cancer Research Laboratory, University of Western Ontario: Honourable senators, I have very little to add to what Dr. Brown has said. He mentioned to you the importance of maintaining a national standard as being one of the chief reasons for the involvement of federal granting agencies like the Medical Research Council, and I could perhaps elaborate on that a little, by describing ever so briefly the way in which the grants panels function. There is not in fact a single grant panel; there are fifteen. There is not one of them that does not have a representative group of experts in the particular field, who function with the aid of referees' comments on most of the applications that come before the Medical Research Council. So there is a very careful screening of the applications which come to the Council as requests for grants.

Dr. Brown did not mention the various sorts of programs that there are in connection with these grants. It is important not only to get a project going but it is important also to keep an overview of the progress being made and, if necessary, to bring the grant to a termination. This is sometimes done, so that on the whole a standard of excellence is maintained based on an assessment of the man's application by his peers.

This applies also to the fellowship training program, to the selection of the Scholars and of the Associates. It is the belief of the members of the Council, and I think it is also the belief of many members of the universities, that this sort of assessment is usually better done on a national level than it is by entrusting it to local levels. The question then comes as to how large a local area is, whether it is a province or a university, but in any case scrutiny on a national level seems to result in a better assessment of worth.

Another point that might be made for federal participation arises out of the amount of money going to medical research. It would be beyond the resources of the poorer provinces of the country, those not blessed with economic resources, to pay fully the costs of the medical research which goes on in them. Another point which has often occurred to me is that if the costs of training university people were borne by the province which contained the university, and then these trained people were to leave that province and go to other areas, as is often the case, the benefits of the training, or the return on the investment if you like, is realized in a part of the country other than that in which the investment was made.

These are some of the points which occur to me in favour of maintaining a national standard with federal involvement.

Dr. LeClair: I have just one word about the problems of new schools. Dr. Brown mentioned there are four new schools being developed in Canada, one in Calgary, one at McMaster University in Hamilton, one in Sherbrooke and one in Newfoundland. These schools have problems which are peculiar to themselves and it is very important that they get started in the right direction. It is also a fact that the quality of the end product, which is the quality of doctor that the medical school can produce, is directly related in many ways to the research effort, to the quality of the research that is going on in that school. Because of this fact the Council has been concerned in a very important way in making sure these schools can be started in the right direction. For example, the budget for the item "Research Promotion" has been increased from $980,000 in 1967-68 to $1,766,000 in 1968-69, and this is mainly to get these new schools started in the right direction.

The Acting Chairman: Now, honourable senators, if it suits your convenience, I am going to suggest that we break off briefly—there is coffee in the hallway—and we will come back in ten minutes, at which time I will ask Senator Sullivan to lead off.

(Short recess)

UPON RESUMING

The Acting Chairman: Senator Sullivan, would you like to proceed?

Senator Sullivan: Mr. Chairman and honourable senators, I would like, first of all, to thank the distinguished chairman of the Medical Research Council for the very kind reference he made to myself. I would like, however, to tell honourable senators that we in Canada, and particularly those in the medical world, are most fortunate in having the men in the Medical Research Council serving under one of Canada's most distinguished medical scientists, Dr. Brown himself. I want that on the record for future purposes.

Dr. Brown, you asked the question: Do we need to do medical research? This speaks for itself. All we have done in Canada does not have to take second place to that done anywhere else in the world. I am thinking of the great work that has been done in this country, and which now has been so well organized and conducted under the Medical Research Council.

Dr. Brown, Dr. Mackenzie said the other day that there were two kinds of research—good and bad.

Dr. Brown: Yes.

Senator Sullivan: He also made the statement that medical research is completely divorced from all other research. I think you would agree with that statement?

Dr. Brown: Yes.

Senator Sullivan: The main interest of the medical profession is the continuation of the Government's policy of increasing by about one-third each year the funds made available to the Medical Research Council. Thus, in the fiscal year starting April 1—that is, this year—the Medical Research Council, as you stated, will have some $27 million to dispose of in the way of research grants as compared to $20 million in the year just ending.

For the benefit of honourable senators who have not read the Gundy Report thoroughly—and I might say that I have read it a number of times, and I read it even more thoroughly than I did the findings of the Royal Commission on Health—I will point out that at page 63 there is a projected outlay for medical research in this country for 1967-68 of $64.3 million. Therefore, you can see the benefit that we as Canadians are receiving from the small outlay under which the Council is operating at the present time.

I understand, Dr. Brown, that the Privy Council of Canada is seeking advice concerning continuing research in Canada, and it has asked the Association of Canadian Medical Colleges for their views. I understand also that it was pointed out at the meeting that the Department of National Health and Welfare, the provincial governments, and various health agencies, have been conducting, and plan to conduct, operational research in the future. You will see what I am driving at in order to get away from the main point of what we had under discussion. The object of this, of course, is to evaluate present health programs with a view to their improvement.

I understand also that the Science Secretariat of the Privy Council was advised that in studying medical research in Canada they should also take into account operational research, and research carried out by non-university agencies, including Government departments and voluntary health associations.

The supply and distribution of doctors is an example of the sort of research that I am sure the Canadian Medical Association, for example, would be interested in conducting, for a better utilization of medical manpower along with the development perhaps of new types of personnel to fill present needs would be desirable. The College of General Practice of Canada and the Royal College of Physicians and Surgeons of Canada would be two other national bodies interested in similar types of research.

Do you consider that this type of research could be considered in the overall plans for future medical research in Canada, or has it been?

Dr. Brown: Mr. Chairman, I think operations research is a most important field that should have the attention of ourselves and others just as soon as possible. There is a great need to examine methods of providing health care in a critical fashion from a point of view of systems analysis and by modern techniques that have so far been employed more frequently in industry than they have been in health care.

The economic benefits to follow work of this sort will be very great. If one thinks of science in terms of economic benefit, if the cost of providing health care could be diminished by only five per cent, one perhaps has the justification for proceeding just as quickly as possible. Men are needed to do the job and there is need for co-ordination and planning.

It has been the view of the Medical Research Council that this type of medical research would be best carried out by the Department of National Health and Welfare, which has the executive responsibility, in the federal Government, in this field.

Here we disagree slightly with one of the recommendations of the Royal Commission on Health Services. The commission suggested that this field of research be under the Health Sciences Research Council, the name they gave to the Medical Research Council. We rather disagree, because we think the capability to do this, and the real potential for developing the expanded capability to carry on operations research, lies with the Department of National Health and Welfare. But I would agree completely with the priority given this type of research. It should be one of the major programs during the next ten years. One envisages an on-going program of medical research that covers the field broadly, with peaks of special effort. One of those peaks of special effort should certainly be operations research.

Senator Sullivan: Thank you, sir.

Senator McGrand: I have several questions in different fields and if you give me a brief answer on each question, that will be sufficient.

You mentioned that there is $27 million available for medical research. Does that include the money raised by cancer societies, arthritis societies, cystic fibrosis societies?

Dr. Brown: No, sir.

Senator McGrand: That is all right. The question is answered. I do not know the number of medical graduates we have from the medical schools each year. What percentage of those graduates go into medical practice and what percentage go into medical research in our universities?

Dr. Brown: The percentage going into medical research is a minority percentage, obviously, but it has been increasing. Another thing is happening. Of those who go into medical research, the number who do so in Canada, as opposed to going to the United States, is growing. Our fellowship program for support of those in research training is one of the most rapidly growing parts of our whole operation. If I may just give you figures for that: the personnel support program cost us $393,000 in our first year and this next year it will be $6½ million.

Senator McGrand: You said "the minority," that those going into research is a minority?

Dr. Brown: That is right.

Senator McGrand: That minority could be anything less than 50 per cent. Could you give us an idea? Is it 10, 15, 25 or only 5 per cent? Can you give it more closely?

Dr. Brown: You might look at it this way. There are about 1,400 doing research in our medical schools at the present time and there are roughly about 25,000 doctors altogether.

Senator McGrand: That is about 5 per cent. Now, what would be the cost of establishing, a medical school, that is, one that would be a first class medical school? There are places in Canada in certain areas where they want or feel they should have a medical school. In round figures, what is the amount of money required to put a medical school into operation, starting with building, equipment, personnel?

Dr. Brown: Mr. Chairman, I should have thought no one could be taken seriously, if you are talking about a new medical school, unless he had access to $80 million, to start with.

Senator McGrand: That question is answered.

Senator Hollett: How many people would that take care of in the area?

Dr. Brown: That would be a school with about 64 or 65 graduating each year.

Senator Hollett: You would not recommend that a small province of 500,000 people would be able to handle a medical school like that, would you?

Dr. Brown: The drives which support a medical school are complex and important. The most important fact in the light of the medical school is its relations with its community; if its community is behind it, you can develop it anywhere. The development of the Mayo Clinic in the centre of the midwestern plains is a good illustration of that.

Senator Hollett: You would need $80 million to do it.

Senator McGrand: I have one more question. Some time ago I read an article in the *Medical Times* October 1965, entitled "More Doctors?" by Perrin H. Long, M.D. In one paragraph, he says:

> The question may well be and is being raised, as to whether or not the medical schools have not run hog-wild in their mad rushes at the more than $1 billion medical research "pork barrel" which is currently available each year. With all this money in view, have not the medical schools lost sight of their primary purpose and function in this country which is to educate students to take care of sick people.

That is taken out of context, of course, but the article is along that line. The question comes up, when you have tremendous expenditures of money, naturally, one would like to know if there is such a thing as a "pork barrel" in research?

Dr. Brown: It is obviously considered that there would be such a "pork barrel". I know Dr. Perrin Long, and all his life he has been making provocative statements like this. It has had a good effect. I think it may be said that there is not a "pork barrel" in Canada, not even a pork keg, but something less than that when one thinks of money for medical research.

It is possible of course for a situation to develop in which the research tail is wagging the dog of the whole medical school. There have been examples of this but not in this country, and I should like to assure you that, happily or unhappily, depending on your point of view, we are a long way from that particular danger in Canada.

Senator McGrand: I do not think he was making reference to Canada at the time.

Dr. Brown: No.

Senator McGrand: I was thinking that there may come a time when Canada's medical research would be affluent enough to support that.

Dr. Brown: The danger that Dr. Perrin Long refers to can scarcely be described as a clear and pressing danger in Canada at the present time. We are a long way from that.

Senator Bélisle: A while ago you said that research in the schools of pharmacy has now become your responsibility. What do you think of sistosan? It is a drug which has been on the market for some 40 years. It is effective in stopping both internal and external bleeding and can be taken before a patient goes to the operating table. The reason I ask is that there has been a certain real controversy. In 1967, the Food and Drug Directorate, without proper—and I used the word that these doctors are using—without proper medical research, have decided to revoke it, or take it off the shelves.

I have here a letter which 52 of them, all local doctors, but local doctors who are provincially known, have written lately to the Director of the Food and Drug Directorate. It is signed by Dr. R. M. Mitchell, who is the ex-president of the College of Physicians and

Surgeons of Ontario. He puts a very strong case. There are four coroners who have signed it and they feel that they are not getting the proper answer from the Food and Drug Directorate. In their thinking, certain lives could be saved and there has been American support on that for many years.

I do not want to prolong this, but could I be permitted to send my information to you three gentlemen so that you can answer my question? This problem is mushrooming. I would say that two-thirds of the doctors in Sudbury are fellows of the Royal College of Physicians and Surgeons and though I may not know what they are talking about, they should. May I mail this information to you?

Dr. Brown: Yes, certainly. Mr. Chairman, it should be made plain that the Medical Research Council does not do research itself. It supports those who do it. We would not, then, have an opinion of our own on this matter. The tools of arriving at opinions are not in our hands but in the hands of the people whom we support.

Senator Belisle: Then, in order to get a higher authority than the Food and Drug Act, we would have to go to the Science Council itself or to the secretariat. We discussed this with them this morning, but they did not know.

Senator McCutcheon: You had better go to Allan MacEachen.

Senator Phillips (Prince): Mr. Chairman, Dr. Brown gave us a breakdown of the expenditures the Medical Research Council makes. I am afraid I did not get the figures. Would you mind giving them to me? I believe one item was 70 per cent.

Dr. Brown: Yes, sir. Seventy per cent on grants, twenty-five per cent on different types of personnel support, and five per cent on research promotion.

Senator Phillips (Prince): What do you mean by research promotion?

Dr. Brown: Development grants, support of different meetings and workshops, travel, the support of a few organizations—this sort of thing—and special items outside the standard programs of grants-in-aid and major equipment grants and the ordinary personnel support programs.

Senator McCutcheon: Would that include programs you felt should be initiated but in which no organization work was being done?

Dr. Brown: There are some of those, yes.

Senator Grosart: Dr. Brown, you speak of personnel support. I do not like to particularize, but I ran across a case in Montreal not very long ago where I was conducting a group of British parliamentarians around the city. I discovered that the bus driver had his M.D. He was proceeding to specialize in his studies. He said that he had to drive a bus because he had four children but could not get any support anywhere. He sounded like a very intelligent man. He said that he tried everywhere but could not get any support and therefore had to drive a bus in his spare time while continuing his special studies—in this case neurology.

Does the Medical Research Council search out cases like this or does it just, like some of the other councils, sit back and wait for applications and then respond to them?

Dr. Brown: Mr. Chairman, there are a couple of points here. The most important question is that first of all the Council supports only those in research training. It does not support people in clinical training, that is, training for one of the clinical specialties. It does not support residents and interns and those specializing. That is education and it is outside our field.

The rest of the question really is this, I suppose: do we pay enough? I think by and large we do not. What we do with our salary schedule for those in research training is to adjust it as frequently as necessary to keep it in line with the stipends paid residents in hospitals in clinical training, so there is no financial competition between these two training streams. So that a man may move from one to the other without financial advantage or disadvantage, we try to keep our fellowship stipends in line with the going rate for residents in hospitals. Now, is this enough? Well, compared with some other things, it is not.

This is really on-job training. Engineers receive on-job training when they move to industry after their bachelor's degree, and this is equivalent to the end of first year medical school for most medical students. If you move forward then for five or six years, in that interval the engineer has been training up to the job that the company wants him to do. He is getting the sort of salary that you know about. But our man who has been paying for his training all this time, except for the last year or two perhaps, may be getting something between four and five thousand dollars no matter how many children he has. The scale of stipend for those in training, either specialist training or research training, is therefore a matter for concern.

What we try to do in the research operation is to make sure that we keep pace with the training stipends for those in the clinical specialties, which are in effect set by the various provincial Hospital Services Commissions.

Senator Grosart: What is the reason for drawing what appears to a layman to be a very thin line between research and postgraduate education? Is the reason financial priorities or is there some more fundamental reason for saying one man should be distinguished from the other, although he is doing postgraduate work and must be doing a fair amount of research in connection with it—not pure research but certainly applied research? Why is the line drawn that fine?

Dr. Brown: There are two reasons, Mr. Chairman. One is financial; we do not have the resources to spend outside our field. The second reason is jurisdictional. It is the old problem of research and education and the degree of federal Government responsibility in these fields.

Senator Grosart: Nobody else is worrying very much about it. All the other councils call education "research" when they need to.

Dr. Brown: That is an interesting qualification, I might say.

Senator Grosart: We have had some evidence to that effect.

Senator McGrand: Medical research is a very broad term. It could be laboratory research or it could be clinical research. It could be clinical observation of patients in wards in hospitals. I would like to know if it would be possible to know the amount of money that is spent in clinical research, in the observation of patients in wards in hospitals, that could give knowledge of medical problems. Is it possible to do that or is that an unfair question?

Dr. Brown: Mr. Chairman, approximately 35 per cent of our grants-in-aid are spent in clinical departments.

Senator McGrand: That would take in the observation of patients on the ward and laboratory tests on materials coming in.

Dr. Brown: That is right, yes.

Senator McGrand: I ask the question because I think you said that you knew Dr. Perrin Long and that he was making provocative statements. I have a quotation from Dr. David D. Rutstein. I believe he is Professor of Preventive Medicine at the Harvard Medical School. He made this statement not so long ago:

> The emphasis on laboratory research has downgraded clinical investigation to a point where its journals are filled with studies on hagfish and Sprague-Dawley rats instead of on well-designed studies on human beings. These animal studies are most important, but they are not clinical investigation.

Now, that is another quotation taken out of context, but could you give me your views on this question of clinical observation? I have practised medicine and I think you learn a lot by watching the behaviour of people. After all, I think you will agree with me that the amount of money spent on mental health research is very small compared with what goes on in medical research. Is that not right? It is something like 10 per cent. And I would like to get your view on the importance of more research and observation on people rather than on laboratory animals.

Dr. Brown: I am very glad to give my view because I feel that the honourable senator and myself feel the same way about it. It is the fact that laboratory research has a cachet or glamour that has diverted people from other types of research which are necessary and can be very productive. There has been underemphasis in the field of real clinical research; the encouragement of it is something that concerns us and we are doing what we can about it. The cures lie, however, in other areas; the cure for the situation will like in the arrangement of circumstances for those doing clinical work so that they can do good research at the bedside. Those arrangements will involve a better relationship between the service load and the time available for research. I think Dr. Rutstein is completely right in that there is need for real emphasis, and I am sure it will come, on the importance of real clinical bedside research.

Senator McGrand: Do you mean in the field of psychosomatic medicine?

Dr. Brown: Generally speaking, in all fields. At any rate that would be my opinion.

The Acting Chairman: I wonder if I could ask a question. I don't remember you making any reference to the part played, if any, by other medical services in the hospitals in this area of medical research, and I have in mind whether it is a fact that important research is done in the hospitals and whether there is support forthcoming to the nursing profession and the dietetic profession and what I might call the subservices of para-medical science of the medical profession, or whether you are pretty well, by your terms of reference, limited to medicine. Now associated with that, the role that is played not only in respect of medicine but these other health services, if I might describe them by this health services fund—this $500 million fund if that is the proper name?

Dr. Brown: The Health Resources Fund.

Senator Grosart: That is for bricks and mortar.

The Acting Chairman: Does some of it go towards training?

Senator Grosart: No, it is all for bricks and mortar.

The Acting Chairman: None for operations?

Senator Grosart: No.

The Acting Chairman: So they must seek from the Medical Research Council and the Department of National Health and Welfare whatever they need?

Dr. Brown: Yes.

The Acting Chairman: Does this mean that the subservices would ask for and get assistance?

Dr. Brown: Yes. Mr. Chairman, the amount of research done by the paramedical groups, the nurses and dieticians, has so far not been very great. It should be greater as their training changes and as their own conditions change. A few of them will do work, scientific work and scientific research, and our Council would be quite prepared to receive applications from them and deal with them. Here again I think we may be back at the problem of the hagfish. There is so much research for nurses to do in nursing and in the provision of nursing services, research that only they can do, that I think it is unlikely that they would get into scientific research, but as far as scientific research is concerned we will accept an application from anyone in a hospital, university or research institute and deal with it on its merits without reference to the degrees that are after the person's name. It will stand on the proposal and on the record of the person and not on his formal qualifications.

The Acting Chairman: Wouldn't these services be important in the area you describe as operational?

Dr. Brown: Yes.

Senator McGrand: The field of psychology is expanding; is there any opportunity for nurses or students who are studying psychology to carry out projects of research in observation of patients in hospital, and the behaviour of patients in hospital? Is there any of that being done?

Dr. Brown: Yes, Mr. Chairman, and the Medical Research Council supports clinical psychology and considers applications in this field.

Senator McGrand: This is done in the hospital in the observation of patients?

Dr. Brown: Yes, it is.

The Acting Chairman: I have another question, Dr. Brown. Is there too much research money being directed to certain areas of work? For instance some of what are described as the more popular areas, cancer and heart research, as compared with some of the other areas that are very important but do not seem to have quite the same public appeal? I have more in mind the appeals to the public rather than to the division or distribution of funds by your Council.

Senator McCutcheon: Mr. Chairman, don't start quarrelling with me now. You have been quite friendly up to this.

Dr. Brown: Mr. Chairman, there are a number of things here. There is not overfunding. As Dr. Mackenzie said, there is good research and bad research which in turn is done by good researchers and bad researchers, but there are no examples of good researchers being overfunded. If many members of the public could see how our grants committees, operate, it would probably be a revelation; proposed budgets are very carefully scrutinized so that the possibility of overfunding is remote. The other very important question is this: As a result of appeals to public opinion and appeals to public emotions is there overfunding of specific fields? The answer really is no. These things are a matter of pressures; we don't tie money to specific fields in our operation. We support now some projects in cancer research; a few years ago we supported practically none because the relative balance then between what the National Cancer Institute and organizations like the Ontario Cancer Treatment and Research Foundation were able to do and what we were able to do was quite different from what it is now. In these things the ability to get money for good work from various sources and the pressures arising from this situation result in a balance. None of the agencies will fund bad work. When they can no longer meet the needs of their field, the applicants can come to us and we work side by side with the voluntary agencies. We exchange lists of applications and lists of grants. In my opinion, there is not any over-funding of specific areas in Canada because of the public monies that are raised and that are applied to particular fields. I would also like to repeat what I said earlier. We very much hope that the voluntary agencies will stay in the grants field and remain strong, because for many reasons it is good to have more than one agency in the fund-granting field.

Senator Phillips: At one time Professor McCarter used to pressure me to complete certain projects and turn in a report by a certain time. I wonder if I could reverse the procedure and ask him if he has any indication as to when we will be able to terminate cancer research.

Dr. McCarter: Put in that way, it is a very difficult question to answer with any sort of time.

Senator Phillips: I was really interested in whether we are making progress.

Dr. McCarter: If the question had been as to progress being made in cancer research, I would say: Yes, very definitely. Progress is being made at several levels. I would have thought that, for example, the discovery of the relationship between cigarette smoking and lung cancer is a very notable achievement of cancer research, one which is able to save a great many lives—if only the social aspects of that problem could be solved!

In the laboratory there are great advances taking place at fundamental levels which are leading, I think, to an understanding of the mechanism of causation of cancer and, surely, in the long run these will pay off, because it seems to me once one understands how it is caused, one might be able—and perhaps this is an article of faith, but I repeat that one might be able—to design methods of preventing cancer from occurring.

In the field of chemo-therapy I think it has proved to be somewhat less encouraging than one had thought some years ago, because although there are some agents that have turned up, as far as I am aware they all have some limitation or another.

Were I to summarize it, I think I would say the advances that are being made are being made in the area of uncovering causative agents in the environment, and also in the area of fundamental research.

The Acting Chairman: Do we have anything in Canada that is at all similar to the scholarship work of the Markle Foundation for the encouragement of a rather select group of individuals? Does the Medical Research Council provide some prestige fellowships of this kind?

Dr. Brown: I would like to ask Dr. LeClair to answer that question.

Dr. LeClair: Yes, Mr. Chairman, there are various areas in which this is done. One is the Centennial Fellowships program which was initiated in centennial year, to encourage training in certain multi-discipline areas. This is a prestige type of fellowship. And, of course, there is the whole Associateship program, designed for the support of career investigators; they are given only to people who have proven themselves to be excellent investigators. In a certain way, these resemble the Markle Fellowships to which you are referring.

The Acting Chairman: Honourable senators, as a rule we adjourn at 5 o'clock. It is a little after that hour, and if it meets with your convenience I would like the members of the committee to wait for a minute or two after our guests have left us.

At this point I would like, on your behalf, to thank them very much for taking the time and trouble to appear before us, to give us such an interesting statement of their important area of research.

It is probable that the work of this committee will continue over quite an extended period of time and, in that event, it may well be that we would like to have all of you or some of you come back and answer some other questions that we may have to put to you.

We are very grateful, sir, and we thank you very much.

Dr. Brown: It has been our pleasure.

The committee adjourned.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Wednesday, April 17, 1968

The Special Committee on Science Policy met this day at 10 a.m.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: Honourable senators, in resuming our meetings this morning I would first like to thank the members of the committee and other senators present for their attendance. We are a great number here this morning, even though the Senate is not sitting.

It is my pleasure now to introduce to you Mr. Christopher Wright. Mr. Wright specialized in philosophy at Harvard and Oxford, although he started by getting his first university education in Chicago. Eventually he went to Columbia University. From 1944 to 1946 he participated in the Manhattan Project, and on that occasion worked at the University of Chicago and at Los Alamos. In 1958 he became the Associate Director and then Executive Director of the Columbia University Council for Atomic Age Studies. He is now the Director of the Institute for the Study of Science in Human Affairs at Columbia University. I understand that this is a very new institution and I hope that in the course of his remarks or during the discussion period we shall be able to hear more about this project.

Mr. Wright is an expert in what is now called more and more the science of science. In making his opening remarks he will use as a basis a paper which has just been given to me. Some copies have been made available to the members of the committee but we did not have enough for everybody. Additional copies are now being prepared and they will be made available to all of you in a few minutes.

Mr. Christopher Wright, Director, Institute for the Study of Science and Human Affairs, Columbia University: Thank you, Mr. Chairman. I will preface my remarks by pointing out that I am woefully ignorant of Canadian Government structure and of your present activities in science policy matters. I hope that in the course of the discussion I will learn a great deal. However, I also hope that I can contribute something to your important inquiry into science policy matters.

Although the special committee's main concern appears to be with the substance of science policy, my remarks are equally relevant to the related need to recognize the potential significance of science policy and policy-making processes. Science policy is an active force, not just a passive force. Those of us concerned with science policy are not interested simply in describing the present state of affairs as it concerns science matters or in general goals.

If I had but a single proposition to put forward it would be that in future science policy has to be regarded as a much more active element in the whole picture, a part of the dynamics of science in modern society.

Science policy is quite a new concept and an increasingly important aspect of public policy. I am sure it is one of the reasons why you are conducting this important inquiry. But it is worth realizing that many working scientists are quite suspicious of the content of science policy. For them, science policy seems like an unnecessary abstraction, something that may divert them and the whole enterprise of science from its proper mission, and therefore, "the less said about it the better".

This is one point of view, a point of view which was prevalent and is still very significant, although perhaps no longer the dominant one.

In any particular context, science policy may be essential to the vitality of a science enterprise. It may even be a substitute for a certain amount of scientific endeavour. The relationship between science policy activities and science activities is much closer than people have thought in the past.

The United States experience illustrates the increasing awareness of science policy. When the National Science Foundation was created in 1951, it was given a mandate to concern itself with science policy matters. In fact, it had difficulty in doing so. Ten years later the Director of the Foundation, Alan Waterman, prefaced a republished version of the famous report by Vanevar Bush entitled "*Science the Endless Frontier*", with the observation that through public statements and published reports the Foundation had, in its first eight years recommended some fifty science policies of a government-wide, national character.

However, this list of policy issues and recommendations was not made public. That is to say, particular aspects of science policy were a matter of public record but not the general picture of where we were going with respect to science policy. But by 1967, as you probably know, the OECD had conducted a science policy review of the United States and had produced its massive and comprehensive study of American science policy. With this report we have even reached the stage of having an international team of examiners which, in effect, cross-examined American officials on science policy.

This is a remarkable change within a ten-year period from regarding science policy as something about which "the less said the better, even though it may be necessary to cope with certain policy issues," to the present state where we are all much more conscious of it and of the need to understand what it may mean and how to keep it alive as a vital and dynamic part of the whole science enterprise.

One reason the study of science policy is so important is that science is no longer as solitary or cultural an activity as it used to be. Science policy now exists in the sense that there can be alternative guides to actions regulating the course of science as well as its applications with respect to defence, foreign affairs, education, resource development, civilian production, and so on. The notion that policy provides guides to action is the key concept.

I do not think it is necessary to give an exact definition to science in this context. It turns out, if one goes into this subject, that when one talks of science one is sometimes talking of scientific knowledge and another time about scientists and scientific institutions, or about the methods and styles of problem definition and problem solving that are characteristic of scientific activity. In practice, one cannot draw sharp lines between these meanings.

In any one of these senses, there is now also a distinctive kind of activity associated with science, and best described as science affairs, which brings about the interaction between science and society and provides the means for implementing science policy.

Only relatively rew scientists are involved in science affairs. And, of course, some non-scientists are also involved in science affairs.

I think one can say science affairs is a necessary part of the development of active science policy concerns. It goes on and there is a science affairs community of individuals, institutions, organizations, authorities, and committees, engaged in the development of programs, policies, and goals in respect to science.

You cannot have guides to action without the element of choice. Once there are real choices to be made, politics enters in. Science policy involves politics and political choices. We must recognize that not only are such choices possible in scientific endeavours but that they are unavoidable. However, this is a rather new concept. Heretofore, the general picture has been that the world outside science only influences science to the extent of saying either "yes or no," either scientists were supported without question as educators or scholars in our institutions of higher learning, or, at the other extreme they were banished or burned at the stake. There was no intermediate form of influence the people outside the science activity could exercise.

This is clearly no longer the case. In fact, the whole line between internal and external influence on science has, I believe, become quite blurred and probably should remain so. The whole concept of setting priorities within science, which traditionally has been anathema to scientists, is now becoming recognized by both scientists and non-scientists as a necessary activity. We have to accept the need not just for priorities with respect to science and non-science activities but also for priorities within the spectrum of science activities.

The actions of the professional and institutional structures of the sciences can no longer be regarded, therefore, as the actions of "nature's agents". That is to say, scientists have somehow felt they were simply following a pre-ordained course of scientific discovery making possible the orderly unfolding of new knowledge. This has been a traditional view, but it is increasingly a questionable view.

From a methodological point of view, science policy is by no means scientifically arrived at or implemented, and I am not sure it ever can be. This is why it is probably useful to avoid the phrase "scientific policy", since this implies a certain quality to policy which may not exist. The prospects are good for improving the means by which science policies are attained and implemented, but if we use the phrase, the "science of science," we must not imply that science policies can be arrived at simply by some scientific investigation in the sense of solving a problem. With my political science colleagues, I find it useful to keep clearly in mind the distinction between making hard political choices and solving problems.

The formulation of science policy is clearly a political act involving choices and decisions. It is not simply solving problems by finding optimum solutions through analysis of data. This is not the methodology that is appropriate to studies leading to science policy.

Science policy and the factors bearing on its formation are becoming a subject of serious study. As such they are essentially a social science study—one which, I think, can contribute to more rational science policy formation.

Natural scientists must make contributions which will sometimes be critical contributions to the studies that will have to underlie a science policy in the future. But their contributions are limited, depending on the relevance of the specific knowledge they possess or on their positions as representatives of particular professions or institutions or as concerned citizens.

There are significant relationships between the impact of a public policy on the development of the sciences and the impact of the sciences on the formulation and implementation of public policies, generally. In this sense, policy for science must take account of "science in policy".

It is useful to make this distinction between policy for science and science in policy, but as we advance in our own thinking we will realize that the two are very closely related and might properly be subsumed under science policy, because science policy is a critical element in the increasingly evident and necessary future orientation of an advanced society. The present popular concern about the year 2000, for example, is undoubtedly connected with our awareness that projects and plans for the future are proceeding at different rates and undoubtedly proceed from different, if not contradictory, assumptions. This awareness clearly gives rise to a concern about the future and about preparing for the future, which puts science and consequent technologies right at the centre of public policy concerns.

Before commenting on general organizational and financial matters related to science policy, I would like to point out that the character and scale of science will have to be reflected in organizational arrangements. Science is an elusive subject. Perhaps it has self-correcting aspects to it, but just when you think you have identified something that you call science, almost inevitably it slips away from you. What is new knowledge or what is at the forefront of scientific inquiry one day becomes rigidified doctrine the next day. Nevertheless, because science is of concern to society, there is always, almost necessarily, a tendency to routinize science activity, to put it in some kind of box and to say, "Now we have taken care of it, because we have given it a label and an organization". It may always be necessary and even desirable to do so, but it is not going to lead to the kind of stability which will allow society to turn its attention to other matters. From a society's point of view the discovery of new knowledge is, let us face it, a kind of irritant. It brings new, unexpected factors into a situation, and we have to be prepared to cope with that.

Science is clearly connected with education and as clearly connected with technology and the productive forces of society. As an introduction to the question of organizational arrangements, it is useful to realize that there are both dangers and advantages if science is irrevocably connected with educational policy and educational matters. It provides science activities with the kind of creative force they need, because of the flow of new ideas and persons through educational institutions. However, science can distort the educational system by putting a premium on research activities which may be deleterious to the educational functions of the system. On the other hand, if science is coupled with technological enterprises, we may very well bring new vigour to technical establishments temporarily, but run the risk of losing the creative quality of the science.

We may wish to discuss these matters in more detail later. All I wish to suggest now is that science is connected with two major sectors of a modern society, education and production and resource development; but it is not obvious what should be its relationship with these two sectors.

Turning to organizational structure and science policy specifically, one can illustrate the dynamic character of science policy and science affairs by noting developments in the United States in the last ten years. Within the office of the President of the United States there is now an Office of Science and Technology, a special assistant to the President for science and technology, a science advisory committee and related individual and collective responsibilities.

This complex apparatus, as well as its counterpart in the legislature, is distinctive in that it is concerned with the totality of scientific research and related activities in the context of human affairs.

Until recently what would pass for science policy considerations and deliberations have been in the context of particular types of scientific endeavour, such as basic research, or areas of scientific and technical work such as atomic energy, space activities, resource development, health research and medical research and the application of medical sciences.

Now, however, we are beginning to develop the organizational and institutional frameworks to rise above these in such a way as to begin to make overall priority judgments respecting these areas—not just to serve as the implementors of a previous commitment to, for example, atomic energy. The current emphasis is on creating institutions that can weigh space-related scientific and technical activities against atomic energy ones, or physics related activities against medical activities.

Until recently we have not had the institutional mechanism for this kind of over-view or for creating effective policy that would implement judgments based upon them. Even now the policy concerns of the Office of Science and Technology have been directed primarily to making sure that full account is taken of what science is doing and where it might lead. The science community has, of course, been especially useful in supplying relevant knowledge and advice in these terms.

Now, there is a growing interest in technological and social assessments and concern about what science and consequent technologies can do to or for our society. This change in focus will require new kinds of staff support and policy-oriented studies involving more social science knowledge, including what is sometimes described as the social science of science and of science affairs. The chief executives and legislative bodies at the federal and other levels do not or should not need science advice as much as science affairs advice except when the latter makes it clear that some science advice is needed in order to discharge a particular responsibility related to science policy. Science policy in this sense can have its counterpart in the context of policy-making at the departmental and local or regional administrative level. It follows that relevant policy machinery and studies should be encouraged at all levels of government. It should probably be regarded as a kind of overhead cost to any science activity since any organization that has a science research and development component under it is probably going to have a science policy component.

Legislatures are supposed to enact public policy but to the extent they fail to participate in science policy-making, they may lose control of public policy-making generally. Science is that critical a variable in modern society. Furthermore, legislatures must become more understanding of science policy in this broader sense if they are to participate in its formulation and effective implementation. In the past many public policy decisions could be taken independently. Legislatures could act on one without any awareness of the effect on some other activity. When one program is approved whereas the necessary complementary program is rejected for other political reasons the prevailing assumption is still that these are separate political acts. But now we know this is not the case and we have to find mechanisms to help everyone understand this situation.

The word "science," as I mentioned before, denotes a kind of fictitious entity. Contemporary science should be regarded as a semi-independent variable. As a matter of policy and organization must not be irrevocably subsumed under or otherwise attached to technology, industrial development, and direct programmed applications of scientific knowledge on the one hand, or to the educational system, cultural development, and the continuing and indiscriminate discovery of new knowledge on the other hand. This does not necessarily mean, however, that a separate department or ministry of science is appropriate. From an organizational point of view it is more important to realize that an active, dynamic, and effective concern for science policy as a focal point for policy-making is more important than the organizational framework for particular science activities, important as those are. Any organization of science will have serious limitations, as I suggested before, but if it is possible to develop a total science policy picture, then the options are always available to shift science activities and to shift the balance of science activity from one kind of social project to another.

So science policy, any kind of science policy, must be studied and generally understood among many kinds of leaders, and to a lesser but critical extent it must be understood as an area of direct and special policy concern. The organizational framework has to recognize that science policy is not a very appetizing subject of public interest. I may be wrong and I rather hope I am wrong, but it is a lot easier for most people to become curious about and interested in a particular development in science than about the complex ways in which a science development may influence many other things of public interest and be influenced by an individual's economic or educational situation, his current prospects or those of his family, the environment in which he lives, etc. The components of scientific activity are too complex to be a very popular area of debate at this time.

There are some general financial aspects of science policy that I find of interest and which I hope we might discuss. First, policy studies and policy-oriented studies pertaining to science policy cost little compared with science enterprises themselves or with the likely costs of the unexpected consequences of new scientific knowledge and its applications. One cannot fault science policy studies in terms of their expense compared with the amount of money—at least in the United States—spent on technical scientific projects. The amount of money spent on considering the implications of these projects and the policy choices available in either implementing or rejecting them or finding alternative projects would be very little. It is remarkable how much money is spent on scientific research with so little investment foresight. This is an observation and not a criticism, since even if, prior to launching a billion-dollar space program or going into a new phase of high energy accelerator construction, one were to say, "All right, we will spend tens of thousands of dollars studying the implications of this policy," it is not clear that this sum could be used productively.

The studies of science policy are still in a primitive stage of development. It is quite clear that we must be prepared to spend modest amounts of money in order to encourage science policy studies on a continuing basis. Sustained long range support of trained and talented personnel in the science policy area is as important as it is in the sciences. In both cases it is usually much more important to support development on a long-term basis than on a short-term project support basis. In the sciences themselves "crash" programs and short-term funding may be advantageous—and I am coming back to this in a moment when I talk about some of the problems of obsolescence—but they may not have a place in science policy affairs. For inexperienced policy-makers to make policy decisions in the midst of a crisis or under pressure is not unusual, but it often leads to bad policies.

Another general financial point I would like to make is that some returns from scientific work may come quickly, but most will be delayed and not separately identifiable benefits to society. It is difficult to make a cost-benefit analysis with respect to science activities. At present an extraordinary amount of traditional thinking, intuition, and laboriously gained but perishable personal experience is involved in identifying and rationalizing what are the returns from science activities. It should be possible to develop forms of cost-effectiveness and cost-benefit analysis which are more appropriate than those now in use for assessing science institutions and programs of support for science, including basic research. However, it is only fair to point out that members of the science community in the United States are generally skeptical of the feasibility of ever applying cost-benefit analysis and program budgeting to basic research activities. They want to exempt science, in the sense of basic research activities, from this kind of accounting procedure. This may not be necessary. The accounting procedures now available may be hopelessly inadequate to give a true picture of the cost and benefits, the inputs and outputs to basic research enterprises. But a consciously developed capability to make this kind of assessment, not only of technological enterprises but basic research enterprises as well, would simply put into more articulate form a lot of the arguments and intuited relationships people now recognize concerning the long-range utility of basic research. I believe this analysis can be developed on a more rational basis, but some persons seem to fear that efforts to link science research with social utility will lead to a rejection of research. If this happens, it will probably be because we have not properly identified what are the real utilities of research—or created the conditions for insuring appropriate use—I am quite convinced of that.

Every society, advanced or less advanced, will have to become more knowledgeable about the outputs from, as well as the inputs to science. It is very easy to formalize the inputs and to assume that science is being furthered by giving a certain amount of money to a science project or by allocating a certain number of trained investigators. One of the faults that has been found with many studies in the science policy area is that they focus on the inputs. Rather than attempt to measure the outputs from the system, it is assumed the output is automatically proportional to the input. This is not that obvious. Despite prevailing assumptions, I would caution against acceptance of any necessary connection between the quality and importance of science research in terms of its output and the costs of doing the work.

It is generally assumed that the cost of scientific work will continue to rise. Estimates have been made of the optimum percentage increment per year as if there were a necessary connection. I do not believe that is true although there is a certain political connection. It is not uncommon for expensive activities not only to get more attention but to be implemented more readily than less expensive ones, simply because they have more political force behind them.

It is only partly true that opportunities for significant inexpensive scientific research are decreasing as science advances. Through science we now know that it is possible to learn a great deal about nature by concerted and expensive efforts, if we choose to do so. But it is less clear that the same knowledge might not be acquired eventually with less effort, or even as a by-product of enterprises launched for other purposes.

There are probably many economic, social, and psychological reasons for preoccupation with the need to move ahead in expensive areas, and to move ahead as rapidly as possible. But the fundmental point is that the distinctive thrust of scientific endeavour is to use organized knowledge and intelligence as a substitute for inefficient, brute trial and error modes of acquiring experience and knowledge. One tries to substitute knowledge and thought for more expensive activities. This is why I question the concept that there is a necessary connection between scientific research and increasing budgets.

Another fundamental point affecting the financial aspects of science policy is related to the concept of obsolescence. I have stressed the dynamic and elusive qualitites of science. It follows that we should take account of the possibility that science is becoming a transient activity for the individuals and the narrowly circumscribed institutions involved in scientific research. Scientists are coming to have a rather short half-life as researchers. It is not possible to measure this trend precisely but certain kinds of science are more like a young man's sport than fields for accumulated scholarship and wisdom. They are activities engaged in and dominated by capable and motivated individuals between the ages of, say, 18 and 35. It does not follow that in the latter half of the individual's working life he will be a scientist or, if he remains active, that the character of his contributions will bearn any resemblance to that of the contributions he has made, or might have made, at a younger age.

This likelihood has enormous implications for the funding of scientific activity. It could be a serious error to equate the funding of science activities with the funding of particular individuals throughout what we hope is their creative or productive life, or, more importantly perhaps, with the contrived funding of a research institution which has no natural life span, even though its contributions to science may have diminished rapidly after the first ten years of its existence.

We do not know very much about obsolescence except that it is a real problem. This is not to say that there are no opportunities related to scientific endeavours for individuals and institutions who are no longer at the forefront of science activity. I am only suggesting that the continuing cost of supporting individuals and institutions in the name of science has to be looked at as part of the overhead cost, and should not be confused with the direct costs of carrying out a program of scientific inquiry, or the developing of scientific personnel.

My final thought on this matter is that the solution to many problems and the approach to many issues of concern for science policy will have to be placed in the context of policies respecting intellectual institutions generally. I have cautioned against too close and permanent connection between science and formal education, but I also feel that intellectual institutions, including our institutions of higher learning but not exclusively those institutions, are going to be increasingly at the centre of what is being called the post-industrial society. Policies for nurturing and circumscribing these institutions will have to be closely tied in with science policy.

These observations and comments suggest the range of issues and approaches that I find fruitful. I would be pleased to respond to your questions.

The Chairman: Thank you very much, Mr. Wright. We will adjourn at a quarter past eleven for coffee. In the meantime Senator Aird will initiate the discussion, and when he has concluded his questions I will go from left to right, which is symbolic this morning because Senator McCutcheon is on my left.

Senator Aird: Thank you very much, Mr. Chairman. I am not sure that I appreciate being on the extreme right.

Mr. Wright, I should like to take you from the general to the particular. We, naturally, coming from the political side, are concerned about priorities. I should like to ask you a general question that relates to your comment on page 2 of your paper which requires, perhaps, a particular answer. In paragraph 6 you say:

> The present popular concern about "the year 2000," for example, is undoubtedly connected with our awareness that projects and plans for the future are proceeding at different rates and undoubtedly proceed from different, if not contradictory, assumptions.

I do not want to put you too much on a spot, but what do you have in mind when you talk about contradictory assumptions?

Mr. Wright: In the technological area, I think the people involved in, let us say, transportation technologies—whether they are concerned with individual or to public transportation, or with land, sea or air transportation—are making certain assumptions about the need for people to move and the desire to do so for business, economic, cultural, recreational or other purposes.

The reasons for people moving may be changing a great deal. Our transportation policy assumes that more and more people are going to want to move between different urban centres of population. At the same time what the centres of population offer may very well mean that most people will want to stay away from them, and be able to communicate without having to move.

Communications technology, on the other hand, has made certain assumptions, such as, for instance, that people want to talk to each other, and engage in a kind of global chit-chat. Much of the technological development on the pârt of telephone companies is predicated on the assumption that the basic means of communication is by person-to-person exchange over the telephone, whereas there are other people who are developing techniques for data transmission that may very well make it not only unnecessary to have the same kind of inter-personal communication, but may also reduce the need for certain kinds of transportation. In these areas of communications and transportation one cannot help but feel that planning for the future may be at cross purposes, or proceeding from different assumptions about the future.

To take another case, that of the environment and our resource development, some agencies work on the assumption that the future will involve an increasing need to develop all our resources, let us say, for food production, and other agencies operating on the assumption that there is a real problem of surpluses and, therefore, are making projections and plans on that basis.

The most serious concern I had in mind in this context relates to the defence area where we have dramatic examples where it may take ten years from the drawing board to the deployment of a new weapons system. In respect of each weapons system certain assumptions are made about the political nature of the conflicts to which the weapons systems are supposed to be relevant. At the same time, the national strategies are changing, although a technology that is designed for an outmoded strategy may have the effect of prolonging a particular political situation or making it more difficult to respond to a new situation.

For example, in the United States again, much of our weapon technology built with the support of the science community has been designed to support a cold war strategy involving super powers. It may have been an error to assume that this will not change, but it is also likely that this technology has led to the maintenance of a particular international posture which one would otherwise like to be able to change, and could have changed if the assumptions underlying, say, weapon development has been different to start with.

Let me mention one other example which relates to the problem of obsolescence. Many people assume that in a scientific and technological society, the unskilled worker becomes obsolete. But in an important sense what we are now finding is that it is sometimes the most skilled workers who become obsolete if they have a very highly developed skill but do not have the kind of general educational background or capabilities that allow them to shift their interests from one area to another.

Yet, our educational system assumes that it is possible to identify in advance a particular skill, a particular field, and devote years of training to help the individual master that field, and that this will satisfy his need and help him meet a demand for the rest of his career. This kind of technical planning about education seems to go contrary to other tendencies in society which are causing this area of expertise to become obsolete or irrelevant.

Senator Aird: Your first example—which, of course, is very pertinent to Canada—of transport and communications, which interests us a great deal, leads into the second question I was going to ask you, because as you answered my first query you pointed out that it was both a political and sociological problem. In your brief you talk about a change in focus. I do not think it is spelled out in your brief, but in your remarks you said the main emphasis would be placed on the sociological aspects. My question is this. Do you have a comment on that? Are you satisfied with the way these decisions are being made? If one has to choose between alternative priorities, are you satisfied?

Mr. Wright: I am not satisfied. I do not believe any of us should be. We have to accept the fact that when people regard themselves as part of the transportation industry, or more realistically as part of one section of it—the aviation, railroad, automotive, or shipping industry—there is a certain self-perpetuating quality to each of these approaches. They continue to engage in narrow research and development about how to improve, for example, aircraft, the mechanics of aircraft production and utilization, without considering how this mode of transportation relates to other modes of transportation or communication.

We do not now have appropriate mechanisms and enough individuals in responsible positions who can be held accountable for having looked at this overall picture and be asked what the population really wants, what its needs are and what choices can be made about alternate modes of communication or transportation. I am not at all satisfied because I simply do not see that there is any alternative at the present time but to permit the more particular technologically orientated sectors of our society to move ahead on their own. If we can create an alternative we can have more open debate as to the relative merits of different approaches.

Senator Aird: This is one of the things that concerns this committee. One of the previous witnesses from England talked about an ad hoc process. I am afraid it seems from the way you are answering my question that that kind of thinking is prevailing, or there is no mechanics of control.

Mr. Wright: It is an ad hoc process now, but I deplore it. I am not in favour of rigorous planning for the future, but I am in favour of creating mechanisms for constantly monitoring and raising as political issues timely questions of priorities and of choice so that we are not always caught by surprise. In the United States there has been, for instance, considerable discussion about supersonic aircraft, but what is remarkable in this situation is that it is so difficult to find out how and when the decisions were made to go ahead. Everybody, including individuals in responsible positions, give the impression that these decisions just happened or were unavoidable, that the forces for a new generation of aircraft just moved ahead almost on their own. Some people would refer to them as unguided missiles!

The first job of science policy is to realize that we are not starting with a static situation. We start with a dynamic situation in which forces of change are already at work and will continue to work; there are new generations of aircraft and of scientific tools such as high energy accelerators, because some people have made it their life's work to design aircraft or accelerators. As soon as they complete one design they carry on, doing what they do best, which is to go on and design the next generation of equipment. This is a natural tendency. Therefore, unless some effort is made to monitor it and raise questions at key points we will always discover that the decisions we wish had been debated and perhaps made differently would have had to have been made five years ago and it is too late to alter that course now. I think we can avoid this kind of happenstance.

Senator Aird: My third question, which will be my last, relates to a passage on page five of your brief, where you talk about cost effectiveness. It obviously affects a number of people, but probably most of all scientists. My previous question related to the mechanics of control. What is being done in the universities today as a mechanic of control in this area?

Mr. Wright: What is being done is being done mostly at the federal level. Thus far it is mostly in the form of questioning basic research activities supported by the federal government for mission oriented agencies. The National Science Foundation has the mission of supporting basic research so it has not undertaken a cost-benefit analysis that would alter its operations. However, the Department of Defence and now the Department of Health, Education and Welfare, including the National Institutes of Health, are beginning to ask questions, more or less formally, about cost effectiveness and the cost benefit characteristics of the scientific research and development activities they undertake and support.

You may have heard about a project "Hindsight" that was conducted in the Department of Defence. It has caused considerable stir. It was a study which endeavoured to identify major technical changes that had been of interest to the Department of Defence over a period of time and to trace their sources in basic scientific research, in order to see whether the kinds of basic research the Department of Defence had been supporting had contributed to these key developments.

The study suggested that there was a relatively loose and very long-term connection between basic research and the significant developments of interest to the department. It has yet to be fully reported but it has caused great concern among scientists—mostly I think because they were quick to see its implications for support of research. Others were also concerned because of the methodology employed in the study. But this is a first study, and we should welcome it. One there is more debate on these matters, people will be forced to pinpoint what they believe to be the best arguments for and against certain activities. Then it will be possible to take account of them in cost-benefit analyses.

This kind of analysis comes out of the so-called MacNamara school of cost accounting, as developed in the Rand Corporation for defence planning and policy control. Granted that these forms of analysis are effective and necessary for defence, we have to be very careful about simply transferring them to the civilian sectors. Several years ago, President Johnson did, however, request all government agencies—civilian as well as military—to begin to develop budget analysis in terms of their mission and the relation between the input and output of what they were doing, including their science and technologically related activities.

However, when you extend the experience of the Defence Department to the civilian sector you no longer have as clearly defined goals or missions.

Earlier I questioned that we were always justified in making certain assumptions about goals in the defence area. In the civilian sector, we are dealing with multiple goals having to do with human needs and desires. These are not completely consistent and therefore any kind of cost-benefit analysis is going to have to be quite complicated if it and related science-based technologies are not to distort these needs and desires.

Senator McCutcheon: Mr. Wright, I wonder if you could tell us something of the background of the Institute for the Study of Science and Human Affairs at Columbia, its structure, terms of reference, its objectives, and what it is proceeding to do?

Mr. Wright: I would be glad to do that, because it is more than a parochial enterprise. It started out about ten years ago from an awareness among some faculty members of Columbia who had had experience in public affairs—most noticeably Philip Jessup, an international lawyer, now an international judge with the World Court; and Professor I. I. Rabi, a Nobel Prize winning physicist—that there was a real gap between public policy matters relating to science on the one hand and academic understanding and study of these problem areas on the other hand. There were certain foreseeable problems which could be identified, with choices laid out, and related problems solved, or solutions suggested, only if universities took a long view. It was up to the university to realize that some issue was going to become of critical public importance say two, three or four years hence and that its faculty members could and should engage in deliberations and studies—in order to come up with insights that would be of value at that time. Persons in public service never have enough time to think ahead. They need the help of members of a university, for whom it would be appropriate to study these problems in advance.

As an experiment in finding a middle ground between academic work and public service, the university formed the Council for atomic age study, a council of academics concerned with studies appropriate to the atomic age, meaning the age in which science may have an immediate impact on public affairs.

As a result of experience, it became evident that it was appropriate and desirable for the university to develop a permanent institutional framework that would not conflict with the ordinary departmental structures and educational functions of the university, but would be able to mobilize the resources of the university to consider problems and issues that were going to be of increasing importance to the future.

The model for this arrangement is regional institute, a concept which was well developed at Columbia after the Second World War when it was recognized that the nation needed to know more about the Soviet Union, about China, Asia, Latin America, Africa and the Near East, and that it was not sufficient simply to have specialists in history, economics, geography, political science, etc., each working within his own discipline. Somehow these discipline orientations had to be brought together and focused on regions of the world that were deemed to be of increasing concern to the nation, in order to develop new insights about what was going on in these regions and to develop more persons who were knowledgeable about the regions.

This implied a problem of policy orientation towards matters of future concern. The Institute for the Study of Science in Human Affairs extends this approach. Apart from the geographical areas of the world that will be of special importance to us in the future, there are certain problem areas of a non-geographical kind. The interaction between science and human affairs is one of them, justifying a reasonably permanent arrangement for continuing study.

This institute draws upon and supplements the resources of the university by serving as a second affiliation for faculty members and others, apart from their ordinary disciplinary responsibilities and commitments. Members have an abiding interest in this problem area and bring to bear their special expertise, whether they be historians, economists, political scientists, socialists or natural scientists.

The Institute has features that are different from those of the regional institutes. Because science is such a dynamic force, it must be assumed that some scholars, as well as individuals concerned with public affairs, should continue their own education in this area. The objective is not to prepare the student by offering knowledge that will last him his lifetime, but rather to develop the techniques which will help faculty members and other persons at mid-career broaden even their own education in ways that will redirect their own research efforts and, hopefully, their teaching as well.

The objective is not to add "the study of science in human affairs" as a new specialty but to make it an integral part of the continuing, more disciplinary oriented activities in the university. While the first objective is to see what can be done in a university context for the faculty, we realize that this task can only be performed if we involve not only scientists and faculty members from other institutions but also people in public service and in the private sectors of our society.

We are experimenting with the identification of problems that appear to be of future importance, giving them priority ratings for study and finding ways to improve interdisciplinary collaboration.

The Institute's programs are educational as well as for the purpose of preparing specific studies and reports. We distinguish between policy-oriented or problem-oriented, and future-oriented studies on the one hand and specific policy studies of direct and immediate use to decision makers. It seems inappropriate and unnecessary for an academic institution to engage in the latter kind of study, but it seems highly appropriate and necessary for it to engage in studies that are more future and problem oriented than is customary in a university and to prepare the ground thereby for a more rational basis for decision making. In contrast, studies which grow out of a discipline itself and the extension of the techniques of that discipline may not have this orientation.

There may be other aspects of the Institute that I have not menioned. It is young and we are still very much in the exploratory phases. For a variety of reasons we have been involved quite heavily in the area of medicine and bio-medical sciences in human affairs. We have also been involved in studies of the marine sciences and the organization and policy issues in that area. We also have been especially concerned at these early phases with the general policy-making mechanisms for the continuing studies of the sort that I have been discussing today.

The Chairman: Is yours the only institution of its kind in the United States now?

Mr. Wright: As far as I know, it is the only permanent one that is explicity committed to working in a general way within an old, established university. There are other programs in particular fields. There are and have been many more or less temporary centres in academic institutions in the United States devoted to such subjects as "Atomic Energy and the Law", "Space Law", or "Automation and Society". In principle we are interested in all such studies and would hope to contribute to them, as particular examples of the more general issue, "Science in Human Affairs".

The closest organization to ours now is, I believe, the Harvard program on technology and society. But this was established as a ten-year research program to produce reports that would be beneficial to society and industry. The Columbia Institute is oriented more towards the refashioning of the university environment in such a way as to prepare students and faculty alike to cope with a changing future.

Senator McCutcheon: Do you publish reports?

Mr. Wright: We are now preparing a first report on our activities. We will also be publishing special studies in the form of monographs and selected papers and books. Rene Dubois of the Rockefeller University is preparing a volume for Institute publication based on a set of lectures he gave for the Institute. Some of the faculty associated with the Institute are preparing individual studies that will come out in the form of books, but there are other mechanisms for supporting and assisting individual work. We are particularly interested in opportunities for interdisciplinary and collaborative studies, many of which will result in reports.

Senator McCutcheon: I assume, Mr. Chairman, that such reports will be available to us.

Mr. Wright: Yes, and I hope to keep in continuing contact with this inquiry, which I think is an extremely important one. It has its counterparts in the United States Congress. Several committees are now looking much more seriously into the general problems of science policy than ever before. I will add, with reference to an earlier question, that other centres of learning are proposing to create institutes similar to that at Columbia. I welcome this, and would hope that a number of universities would have continuing centres of inquiry in this area, but particularly suited to local circumstances, as ours takes account of Columbia's location in New York City and its faculty resources in such areas as international affairs, medicine, the pure sciences, and the social sciences.

Senator McCutcheon: Thank you very much.

Senator Grosart: Mr. Wright, my first question relates to what I think you would call the methodology of government support of science research, particularly the question of who should get the money. In the last decade there seems to have been a strong trend away from spending in government laboratories to spending in support of research in universities and industry and so on. I have some figures from our own Dominion Bureau of Statistics which indicate that, for example, in 1955-56 in Canada 70 per cent of total Government research spending was in Government laboratories whereas today it is 27 per cent. In the United States a similar trend is seen by the decrease from 78 per cent in government laboratories in 1963-64 to 19 per cent with the switch being from government laboratories to industry. Will you tell us, what is the reason for this very drastic change in science policy and is it in your opinion the right direction in which the policy should be going?

Mr. Wright: I would suggest that the reason for the shift is basically sociological. It is a matter of where the people are who by general agreement are the most willing and able to pursue the kind of studies deemed desirable or necessary. There is no inherent reason why the academic or the industrial environment is more attractive than the government research laboratory. It is a matter of career perceptions and the atmosphere of vitality. I would caution against a simple analysis of the budget figures. Certain kinds of scientific inquiry are very expensive because they involve expensive facilities, whereas others do not. One has to look at the nature of the scientific inquiry that is being supported before one can discuss the significant trends. Even taking that into account, I would have to agree that the thrust has been away from government laboratories. This is congenial to the United States where the philosophy of pluralism and decentralization of activity is welcome and we have been able to afford many different self-sustaining centres of scientific activity. The United States has not had to direct all its resources to one national establishment. However, this will not remain true. In the field of high energy physics you may find a change in the next generation inasmuch as there will probably be one one high energy accelerator of largest canacity in the United States the people involved in this field will have to gravitate to that national centre. Whether you regard that national centre as public or private is rather irrelevant. In this case it will not be a government laboratory because it will be run by contract with a specially created university group, but in the long run it will probably run into the same problems that government laboratories have encountered in attracting and holding creative personnel.

I ended my introductory remarks with the observation that centres of scientific activity will have to be thought of in the context of general centre of of intellectual activity; that the stimulus and response required by scientists to keep them intellectually alive is going to require close intellectual proximity to people who are not necessarily scientists but who are thinking about problems which can be related to those of the scientists.

Government laboratories have often been deficient because they have been isolated from intellectual communities and have been identified with a fixed mission or agency. In my view this has had an inhibiting effect. However, this has not always been the case. We should remember that in the 19th century government laboratories in the United States did not have the same relationship to universities and industry that they do now. They were all part of the same climate of scientific activity albeit a less sophisticated one. There was a flow of scientists in and out of government laboratories. In fact, the Government recruited much of its personnel at the bureau level, from the universities. But as the sciences and universities have developed and government laboratories have been constrained by closely defined missions a split has also developed. In the interests of supporting the best and most active scientists, funds have gone away from government laboratories to the private sectors.

Senator Grosart: Is there a danger that if there is very heavy financial support for research at universities it will affect the teaching position?

Mr. Wright: Yes, there is a definite danger. I would caution against too close an automatic tie between research and education. We know there are many arguments for a close tie and one can make many comparisons between countries in this regard. I know that it can be mutually beneficial to involve students in research activities. However, research activities do have a self-directing characteristic and become more and more specialized. It may well be that they lead students astray. Support of research activities in the universities has led to a proliferation of courses that are too specialized. In many cases the courses are designed to match the interests of a research-oriented faculty rather than fill the needs of the student who should be encouraged to keep open his options as to where he goes. He should receive an education and guidance that does not prematurely commit him to follow one line set by his professors. I am not sure all research environments help meet this need.

Senator Grosart: Is there also a danger that the provision of very large sums for industrial research by government will lead to an undesirable level of government involvement in the marketplace? For example the Ministry of Technology in the United Kingdom would indicate that there is a tremendous degree of government involvement in the marketplace. Do you see any danger of that here?

Mr. Wright: This is an area that requires further study. It is very complex and has some new features. The Government in the United States has been both a stimulator of industrial development and the ultimate consumer. There are more and more industries or companies within particular industries that essentially look to one customer and that is the federal Government. Whether that customer is buying a mass-produced product or something resulting from research and development is irrelevant. The problem is that you have private industry in some cases engaging in activities which the Government is prepared to buy and this creates the danger that the success of these industries depends on their persuading the Government that it ought to have this particular product, whatever it may be.

This situation led President Eisenhower, in his farewell address, to make the famous remark about a technical-industrial-military complex and its exaggerated influence on public policy, including science policy. He advocated open discussions that would create more options, so that this set of interests did not have undue influence by default. As I interpret his remarks, he was not saying we should legislate against new kinds of relationships between industry and Government, but that we should know what is happening and strive for open decision-making.

The role of Government as a stimulator of industrial activities that must become viable in the general market place, presents quite another problem. It has been the experience in the United States that the real problem is not so much that industries have turned to Government, but that many have not done so. Characteristically the influence of science and advanced technology has been the creation of new industries, most of which have the Government as a consumer, rather than the revitalization of old industries and activities. To take the most extreme examples, it has become a matter of concern that the construction industry or the railroad transportation industry, for example, have not turned to research in order to re-define some of their own activities. Perhaps some industries are too much self-energizing whereas others are not energized enough, either internally or externally. The Government has tried. In the Department of Commerce, a former Assistant Secretary for Science and Technology made strenuous efforts to get old-line industries to be more responsive to Government encouragement of research to help them perform their functions more effectively. The industries tended to resist these efforts.

Senator Grosart: I am every interested in your remarks on the cost-benefit relationship. It so happens I read a statement on this by a distinguished Canadian. I wonder if I could ask for your comments on it. It seems to me that it might run somewhat counter to your own experience, but it is a statement made by Professor D. L. Mordell, the Dean of the Faculty of Engineering at McGill University. Although I am quoting only a small extract, I am not taking this out of context because it follows the trend of his whole discussion. This is from *Canadian Business*, the April, 1968 issue:

> There are two really substantial reasons why research might be supported by the taxpayer. These reasons are both divisions of the one fundamental reason that research can be justified only as a government expenditure if from the results of this research, economic benefits, are going to be returned to the taxpayer.

Mr. Wright: Perhaps I would not agree with that statement now because I would be fearful that in the present context we would necessarily have to take too restrictive a notion of what we mean by "economic benefits...returned to the taxpayer." I would hope that in the long run and with a more developed utilitarian calculus, we would be able to demonstrate how all important research does contribute to and is a necessary part of long-range development of certain kinds of public services, educational enterprises and other things of benefit to taxpayers in the long run, and would be justified on that basis.

So, in an enlightened, utilitarian sense, I would agree with that statement. But given present indicators of costs and benefits and the way in which we analyze and use budgets, I think it would perhaps be a mistake to justify research support and set science policy in those terms alone.

Senator Grosart: Should the ultimate benefit to the taxpayer or, let us say, to the public at large, be an essential element in the decision making, the Government science policy making?

Mr. Wright: I do not see how you can avoid speaking in terms of ultimate benefit to a society, although even there one can demonstrate there are certain activities that are in the ultimate interests of mankind as a whole, but not necessarily any more in the interests of Canadian or United States citizens than others. There is the danger that if you justify activities just in terms of the special interests of a particular population or citizens of a particular country, you may hurt yourself as well as others because you have failed to exploit opportunities which would benefit the whole of mankind and, thereby, indirectly benefit a particular nation. That is one qualificaton.

The other qualification is that the concept of the citizenry as a whole is hard to work with. Maybe we have to take a more pluralistic view and say it is very difficult to measure what is in anybody's and everybody's interest; it is easier to measure what is in the interest of a particular people.

I would develop this point one step further. The organizational arrangements for developing science policy have to be responsive not just to the general will or to the public will as a whole, but to particular interests. If you accept the political dimensions of policy making, you have to recognize and even welcome the existence of special interest groups, and the fact that support for certain science-related activities will vary from one combination of special interests to another. The problem is not to discourage these arrangements but to have a science policy mechanism that is responsive to the balance of interests in any particular case.

In this sense I would say one should not suppress special interests and the benefits of science to particular interests, quite apart from their benefit to a nation or to the citizenry as a whole.

Senator Grosart: My final question arises out of your comment on the universal aspect of the benefits, the point regarding the supersonic planes raised by Senator Aird. It seems obvious in the policy decision, say, with respect to supersonic planes for Canada, there are a great many elements not easily subject to scientific decision—consumer demand, the broad economics of transportation, the essential question being how important it is that we go faster from "A" to "B" in the next 10 years. The elements are so complex, both nationally and internationally, because, obviously, if you can fly from New York to Europe in three hours and from Montreal in six, then Canadians are going to go from New York.

My question is: Is there any trend or progress being made towards international decision-making or international coalescing of national decisions in these broad areas of science policy? Disarmament is a case in a related field, but is there anything in the ordinary field of human progress that is being done?

Mr. Wright: It comes to my mind that perhaps communications satellite technology is a development where there has been an international effort. The COMSAT organization in the United States, and counterpart organizations elsewhere, have organized INTELSAT, which is trying to develop the general capability for use of communications satellites on a global basis.

This is a promising effort. Almost necessarily, this kind of technological development should lead to questions of the sort you suggest. I think, however, the solutions found thus far are not perfect, and one can see how the kinds of decisions and plans being made are perhaps overly influenced by certain short-range interests as distinct from long-range ones.

At least, we have a prototype effort to use a new technology, and to ask fairly early in the planning just what are the major long-range considerations in terms of human needs that should be taken into account, as well as the more short-range considerations of economic investment and return.

Senator Leonard: I have just one question, Mr. Wright, and it relates to paragraph 8, which is at the top of page 3 of your submission, and which deals with the organizational structure of the United States. You say:

> Within the Office of the President of the United States there is now an Office of Science and Technology, a special assistant to the President for science and technology, a science advisory committee and related individual and collective responsibilities.

The following paragraph suggests that changing times require changes. In your remarks you said also that you were not thinking in terms of a department of science policy.

My question is: What further mandate or authority or power is required for such an office, in your view, or what suggestions do you have in this respect? Is it a new organizational structure that you have in mind, and, if so, what kind of powers, mandate, or authority should be given it?

Mr. Wright: In the United States—and I do not know whether this experience is relevant to your particular situation or not—I can see an evolution in the concerns of this office, which is at the highest execution level of government, from a science orientation in terms of what science is doing and where it might lead, to a concern about what science and technology can do for society. I do not think we require too much new legislation or authority for that purpose. This interest will evolve as the public and the President and the Congress demand justifications for programs in those terms. This office may suffice, for this purpose. The Bureau of the Budget has played the overseer role, and has asked questions about the benefits of various programs in terms of the legislative goals that have been set. However, it is no longer sufficient just to work in terms of financial budgets. It is necessary to account for trained manpower and have a kind of manpower budget as well as a financial budget. This is a very difficult task, requiring knowledge of the flow of skilled manpower and how to take account of such things as obsolescence. It will require considerably more staff and technical capability than we have at present.

On the other hand, if such an office is going to be effective at the policymaking level it has to remain small. Therefore, if there is anything new and it has to take place at that level, then there has to be the development of adjunct study units. Some of these could be probably be established outside of government. There have to be studies and analyses that will help a relatively small staff make sure that the appropriate policy processes for science policy remain effective. So one organizational development at the policy level is likely to be the development of more studies and public discussion and the development of relevant factual information. Even if this analysis takes place outside of government, it will be relevant at this level, and helpful to these executive office staffs.

The other development that makes this organizational development for policy control feasible is an alignment of relevant operating agencies and departments of government such that none are so strong that they become independent centres of policy making with respect to some facet of science policy.

The President has policy power if he is in a position where he can make certain choices with respect to any technological development and decide whether to go ahead or not, or to permit one department or agency to expand into a new field in lieu of another organization. If he has no choice, if there is only one place in government where something can be done, then this limits the amount of policy he can have in respect of that subject.

So the legislative action that may be appropriate to the development and implementation of science policy is to ensure that at the operating level of goverment there is a certain plurality, or even a certain amount of competition within the agencies, provided this does not get to the point where competition leads to gross wastage of resources. I think the scale, size and authority of operating agencies, and their dependence on or independence of each other, has a lot to do with how effective an office of science and technology can be.

Senator Hays: Mr. Wright, you mentioned earlier this morning that as Director of the Institute for the Study of Science in Human Affairs you were looking at China and the Soviet Union, and that sort of thing. Why have you been looking at these problems—or, are they problems? What are you trying to find out from China?

Mr. Wright: I made two references to foreign areas. I said that we were using the model of how a university goes about studying a foreign area as a model for studying science in human affairs. This has to do with the ways in which scholars and practitioners are involved in the Institute's programs. We are also interested in science and science affairs abroad for comparative purposes, in order to illuminate what is going on in the United States. I teach a course, for instance, that is a comparative study of Government and science in the Soviet Union, the United Kingdom, and the United States.

My colleagues and I have also been studying science and science affairs in the Soviet Union and elsewhere because this is a factor in international affairs and is something our nation ought to know about.

Under the auspices of the institute, a group is studying the problems of science and technology in developing countries. From such studies we hope to develop individuals who are better able to engage in science aid and technical assistance programs, or who will improve our conceptual framework for understanding this important area of foreign policy. In fact, the organization of science policy with respect to foreign policy is a particularly touchy one, warranting further study and training. From some points of view the training of diplomats and scientists leads them in opposite directions, and yet there obviously is now a common field that has to be brought together and with which they must somehow be concerned.

Senator McGrand: I have a short question. I wrote this down as you were talking: "Some scientists are suspicious of science policy". I should like to know what they are suspicious of. Is there any serious threat or danger to our well-being in particular areas?

Mr. Wright: Any danger of what?

Senator McGrand: Danger to our well-being, and in what particular areas if there are such dangers?

Mr. Wright: I think there are two questions there. The first is the suspicion on the part of the science community of science policy discussions and deliberations. This has historic origins in that science used to be very much an individual enterprise, a cultural enterprise in which you could say it did not make that much difference to an operating society whether there was any advance in science or not. Human affairs could have waited another century for the kind of integration of physics concepts that Newton brought about.

Science was an individual activity carried on at the leisure and the whim of the individual, with the individual and his closest intellectual colleagues developing their own standards and procedures. It is understandable that external influences now through something called science policy may do more damage than good, and we all have to be aware of that possibility.

The problem is that scientists who are suspicious tend, I think without examining the question, to assume that any external influence other than material support without question will inevitably be more damaging than beneficial. In other words, they are making their own cost-benefit analysis from their own point of view, but not so that it can be examined.

I do not interpret this concern on the part of many working scientists as a concern because they are engaging in something clandestine of which society would disapprove if it knew about it. I do not think that is their argument at all. In fact, their argument is usually the other way. Scientists are often convinced that they are carrying out the will of God by learning more about nature and that the more we learn the better, and that ultimately knowledge is better than ignorance. Put in that form this is a very good proposition.

However, from the policy point of view the question is not knowledge versus ignorance but the ordering of knowledge. What is quite clear now is that the knowledge of nature and of certain things man can do to manipulate nature is far ahead of applicable knowledge of how to control this use of scientific knowledge for the benefit of a society. In this sense there is a danger. Whether the danger comes from inside or outside I do not know, but I think we have to recognize that we are in trouble if we are continually coming up with new knowledge about how to do things but not with new knowledge about how to decide whether we should do them. Since this is a serious danger, we should fall back on the conservative proposition that when in doubt, do nothing.

Some scientists say it is not new knowledge that is dangerous, since it is the technologists who apply the new knowledge and are accountable. There should be social control over technology but not social control over the discovery of new knowledge. This may be true in theory, but what worries me, at least, is that if often turns out that once the new knowledge is available it is very difficult to control its use. It may be we have to go back another step and control its use by keeping it undiscovered, perhaps like keeping known reserves of oil underground until it can be used responsibly.

Senator McGrand: You feel this could happen? You feel this is possible?

Mr. Wright: Very much so.

The Chairman: In other words, if we want to organize change we will have to organize knowledge?

Mr. Wright: That is right, yes, at least give some order to knowledge.

Senator Bourget: Is the committee on science and technology which is attached to the office of the President advising the President mostly on defence research or on all kinds of research; and secondly, how do you staff this committee?

Mr. Wright: The historic origins of the committee were very much related to defence, and its purpose in the fifties was to provide the President of the United States with alternative sources of advice distinct from those available through defence channels. Individuals associated with the President's Science Advisory Committee and the Office of Science and Technology including its third director, Jerome Wiesner, of M.I.T., point to the contributions of the committee and the office to the development of new outlooks towards arms control and disarmament, developing the concept that security is enhanced by arms control as distinct from an arms race.

In the course of time this attention to defence has become relatively less important, and the apparatus has moved towards more general reports about science and problems that might be amenable to scientific solutions. At the same time, the committee and the office have tried not to become just spokesmen for science. The National Academy of Science in the United States has taken on that role and has issued reports on the next ten years in chemistry, physics, biology, mathematics and so on. However, the working relationships between the Academy, the office of Science and Technology, and the Science Advisory Committee and their distinctive functions are still not entirely clear.

The staff of the office of Science and Technology is deliberately kept small. It has about 17 professional persons now. It has to be small if it is to have close proximity to the President. It started out in the White House as the staff of the President's Science Advisory Committee. As it increased in size and acitivity it was removed somewhat from the President. It is now part of the Executive Office of the President instead of the White House staff. This is a detail, but it has significance.

The staff includes individuals with science training and experience but also many with a predominantly social science background. Our universities have a special responsibility, I believe, to prepare persons for this staff work. The members of the Science Advisory Committee are almost all physical scientists with university affiliations.

Senator Bourget: Are the members of the advisory committee appointed for a fixed period?

Mr. Wright: Yes, a three-year period. The committee set its own rule against accepting immediate re-appointment. It thought it desirable to rotate membership. Some members come back after a period of time. Some who have been deeply involved continue as consultants-at-large. Of course, the committee operates mostly through *ad hoc* panels which involve many more scientists and others. The committee as a whole does not now deliberate as much as it did in its early days. From a political science viewpoint one can see a definite evolution and routinization, if you will, of the activities and role of the committee since its elevation to the Presidential level late in 1957.

Senator Bourget: Thank you.

Senator Cameron: I have two or three short questions. First, I think this is the first institute of its kind in the United States?

Mr. Wright: I believe it is the first with this broad, permanent mandate.

Senator Cameron: Secondly, are you aware of similar bodies in other countries at the present time?

Mr. Wright: Yes.

Senator Cameron: Where?

Mr. Wright: I am aware of individuals and small groups involved in the process of creating such bodies. There are a number of efforts in the United Kingdom. One that comes to mind is the science policy study unit at the University of Sussex. Not being committed to the established organizational lines of older universities, this university has created this unit, which is part of the university but also carries on work in collaboration with the government.

In other countries, as in Sweden, there are individuals actively involved in science policy studies, but in most countries, one would probably have to look at government offices for the counterpart of what in the United States can be done in the private sector. Most countries do not have the private university structure. Within governmental offices, the OECD Directorate of Scientific Affairs, for example, has prepared the reports on science policy already referred to. It is certainly engaged in the study of this subject as well as in implementation of relevant policies for OECD itself.

UNESCO has an office that is taking an increasing interest in science policy matters.

Some developing countries are creating science policy units. There is a considerable proliferation of such centres, yet there is still a much keener awareness of the need to do something than there is of exactly what needs to be done.

Senator Cameron: What is the source of funds for the Institute as presently constituted? Is it all from Columbia University, or all from a foundation, or does it get governmental funds as well?

Mr. Wright: It is funded by the university with funds given to it by foundations for the use of the Institute. The University received a founding grant for the Institute of $1 million from the Alfred P. Sloan Foundation. There have also been grants from other foundations, and from some other benefactors either for general purposes or to develop work in a specialized area.

We have not sought government funds as yet because we wanted to maintain a certain independence over our own program development and not be prematurely committed to a particular type of program or inquiry.

We accepted one contract for an inquiry of interest to us. This was with the Commission on Marine Science Engineering and Resources, which was created by the Congress to report on a national program for ocean development. And we agreed to collaborate on a study of federal organization for marine science affairs.

One other point of general and financial interest is the plan, which has not been fully implemented as yet, to endow about five new professorial chairs. The holder of a chair would have the commitment, as long as he held the chair, to focus his studies in the general area of institute interest. Some studies cannot be done by *ad hoc* or collaborative activities. It is necessary to have a corps of people committed to this effort. On the other hand, it would not be sufficient simply to support individuals without new institutional mechanisms for bringing them together across the department lines.

Senator Cameron: I realize that the institution is new, but to what extent has it been able to establish areas of priority so far? You mentioned transportation and housing and things like that. Have you as yet set out anything saying, "Here are fields that must be looked into"?

Mr. Wright: We have to distinguish between priorities for study by somebody somewhere, and appropriate priorities for this institute, given its particular situation. We have priorities which cause us to pay special attention to the fact that Columbia has a certain strength in the social sciences and international affairs, the basic science, the geophysical sciences, and the medical area.

As for national or world priorities for science policy studies, I would say that the concern about science policy itself, and the mechanisms for studying it and implementing it, are all of priority concern. There is a limit to how much can be done on an *ad hoc* basis. But if we can develop new understanding of the whole science policy process, a lot of developments may follow from that. The priorities should also reflect the spread of scientific knowledge from the physical sciences, which have been dominant in the last decade to the life sciences and the geophysical sciences, so that we are better prepared to understand their meaning for human affairs.

Senator Desruisseaux: In the field of science, many nations are claiming leadership because of their scientific policies. Has there been any apparisal of most of those scientific policies?

Mr. Wright: There have been no real appraisals. The closest approach thus far is the series of studies of science policy now being conducted by OECD. From this review of activities it will be possible to make certain kinds of comparaisons, at least with respect to specific "inputs" into science. It is a different matter to compare outputs and the net benefit for a society or mankind of science and of science activities and of their connections with science policy. Such comparisons are now hopelessly confused by concern about the number of Nobel prize winners a country may have or the number of technological "firsts" that they may claim. There should be less emphasis to these kinds of simple-minded quantifications of the payoff to a society of its science capability.

The Chairman: Would you, for instance, care to comment on the OECD report on the United States?

Mr. Wright: It is a massive document. It is regarded as invaluable to students of the subject and the most comprehensive study thus far of the elements of science policy in the United States. It illustrates the point that science policy is becoming a difficult subject to study because of the amount of relevant data involved. Whether or not it will be of value to other countries I do not know. Of some interest too is the confrontation between the external examiners and the American officials. I suspect preparation for this confrontation, the preparation of background documents and the rethinking of positions by officials, have been of special practical value.

Inevitably, the confrontation can only touch certain major points. Perhaps it tells more about the perspectives of the examiners, than about the real problems of the United States.

The Chairman: But, as a document describing the present situation in the United States, it is fairly complete, wouldn't you say?

Mr. Wright: I think it is more complete than anything else. I am sure it is only a first generation document and that it will stimulate us to be clearer in our own minds as to what are the real variables in the American science affairs and science scenes, and that we will be able to distinguish these more carefully in future.

Now, the relationships between basic research, applied research and development, and between science and technology, are very confused. Science policy must pay attention to the connections and differences, but the description of what is going on and the aggregate statistics about manpower and about budgets inevitably blur the distinctions.

Although the best available information is put together in this report, my suspicion is that the budget, manpower, institutional, and program classifications which have been developed are quite inadequate for science policy purposes. For instance, there are about 100 universities in the United States with substantial scientific research capabilities, and 20 of them absorb 80 per cent of the research funds. But these figures in themselves do not mean much until you begin to distinguish the different functions of the universities and look more carefully at what the funds are being used for and the context in which they have been received. This kind of analysis has not been carried out.

Senator Thompson: Do you think you are going to have to write in constitutional control of technology?

Mr. Wright: I would caution against thinking about science policy in constitutional or even in legislative terms. The whole situation is too fluid for that. It is more important to have active monitoring and administrative capability to make decisions. If neatly phrased guidelines are established without an implementing mechanism, they are bound to become outmoded or irrelevant. One of the problems for legislatures is that events move too fast for ordinary kinds of legislation. In the United States we have had to develop an increasing number of regulatory agencies which work in a quasi-legislative way but with staffs that are constantly adapting the regulations to meet changing technological circumstances.

The Chairman: Mr. Wright has to leave at three o'clock this afternoon and he must have lunch before that, but I will accept one final question from Senator Grosart.

Senator Grosart: Mr. Wright, have you reached any conclusions as to over-all superiority or particular superiorities in the science policies of the U.K., the U.S. and the U.S.S.R.?

Mr. Wright: No, I really have not.

The Chairman: This is a direct call for a value judgment.

Mr. Wright: That is right.

Senator Grosart: That answer satisfied me. Have you published anything in this area?

Mr. Wright: Not on comparison.

Senator Cameron: If it is in order, Mr. Chairman, I would like to express the appreciation of the committee to Mr. Wright. He has given us a very lucid talk this morning. One of the intriguing aspects of it is that we could sense he has a tremendous reservoir of additional information which he could have given us. This has been one of the exciting aspects of this meeting. I hope we may have the opportunity of going into this question further at some future time.

The Chairman: I am sure Senator Cameron has expressed the views and opinions of all members of the committee. We are all very grateful to you, sir, for coming here and enlightening us. I do hope that in the future we will remain in contact and perhaps, if you are free to come, you might respond to some future invitation when we are at a later stage of our inquiry.

Mr. Wright: Thank you very much. I have enjoyed it a great deal. I simply wish to emphasize that I have expressed my personal views. I have no doubt that other people from the United States and elsewhere might take strong exception to some of them.

Senator Leonard: The views you have given are so much the better for being your personal views.

The committee adjourned.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Wednesday, April 17, 1968

The Special Committee on Science Policy met this day at 3 p.m.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: Honourable Senators, on behalf of the members of the Committee, I would first like to welcome Dr. Hans Selye. As many of you already know, Dr. Selye is Director of the Institute of Experimental Medicine and Surgery at the University of Montreal.

But before accepting this responsibility, Dr. Selye had a long and distinguished career as a scholar and scientist. I will not give you today the complete list of his achievements and of the awards he received in recognition of his contributions to the well-being of man. His complete biography will be printed as an appendix to our proceedings. I would like, however, to mention that Dr. Selye was born in Vienna and got his basic education in medicine in Prague, Paris and Rome. His famous and revolutionary concept of stress opened up countless new avenues of treatment for many diseases, namely, what I would call the diseases of civilization. This has been up to now one of his major contributions to the improvement of mankind. I suppose that this is perhaps a bad place—in the Senate—to raise the problem of stress; perhaps the House of Commons would be a better place. But in any case it was really a basic achievement and we are all very honoured to have you with us today, Dr. Selye.

I hope that you will be able to explain more fully how you arrived at this major discovery.

Dr. Selye is also the author of a more recent book entitled *From Dream to Discovery; On Being a Scientist.* In the preface of his book Dr. Selye says, and I quote him: "The object of this book is to present certain problems of science through the portrait of one scientist—the only one I know very well. I have tried to do a ruthless autopsy of my mind, describing and analyzing all of its characteristics as objectively as I can."

Dr. Selye, I hope that this afternoon you will try also to make an autopsy of our science policy, although that science policy is still very much alive as fortunately you are too. This afternoon, instead of writing your letter to "Dear John" I hope that you will write it to "Dear Pierre".

Dr. Hans Selye, Director, Institute of Experimental Medicine and Surgery, University of Montreal: Mr. Chairman, Honourable Senators, I would first like to tell you how happy I am to be here and to have this chance of outlining some of our ideas.

I would like to start by pointing out the limitations of my competence to act as a witness, I think it is only fair to warn you that I know very little about science management or science policy; I have never been actively engaged in any national or international science organization.

Unfortunately, I also know very little about politics in general, but I do have 40 years of experience in the laboratory with actual research itself. In listening to me, I think it is the views of the experienced man at the bench, in the lab, to whom you should listen; you should not take too seriously some of the suggestions I may make on the national organization of science, because they are dreams, perhaps utopias.

In your letter inviting me here you pointed out that it is daring suggestions you want. I will make them, and I do not expect you to take them too seriously, if you find that they are not very practical.

I think in the consideration of science policy there are several points which ought to be mentioned at the outset. Whether we should centralize or not is perhaps one of the leading problems. It is very difficult to get the best out of research without central direction; there is too much duplication; there is too much exertion of effort in centres which are not prepared for certain types of research. You need a certain "critical mass" of scientists who can get together, form a scientific community and exchange views.

On the other hand, the danger of centralization lies in the infringement upon scientific liberty. If science is too much directed, if it is too much centralized, it tends to become sterile, because people do not do what they really want to do most, but rather what the science policy dictates to them.

On the basis of whatever conversations I have had with colleagues throughout the country since I received this invitation, I think that it would be very difficult to convince many people to centralize much of our effort. Almost every centre throughout the nation jealously guards its own independence. Yet a certain degree of centralization would be very welcome. If this is feasible we should have a clear idea of what we want to accomplish with it. It seems to me that at the present time we would do well to specialize in certain fields of research rather than attempt to be excellent in all fields, because real excellence cannot be achieved across the board in all types of science. However, we could select a few areas in which we have already shown a certain competence and in which we have already earned international recognition.

I know from several trips to Russia for instance, what difficulties arise if science is too much centralized. To give an example, the great development of physics and mathematics in the Soviet Union was accompanied by a corresponding decrease of emphasis on the life sciences, which is now felt very much. Also, if centralization goes too far, it is extremely difficult for someone who has not made a success with whoever is in power to stay in science. If you have many organizations independently subsidizing science in different provinces and also at different levels (government, private donations, industry, and so on), and somebody's idea is not very well received by one body, he still has other chances to succeed. If science is over-centralized, this becomes difficult. I do not say it becomes impossible, because with the diplomatic approach it should be possible, but I do think we ought to try to develop a special national excellence in certain fields. I would mention, just as an example, the Swiss who are well known for watch-making, and various other countries have their own specialties in industry. If we do develop a strong Canadian scientific policy, we should try to achieve not mediocrity in many areas, but excellence in a few.

I must again point out my limitations, in fact, prejudices, because being engaged only in a certain type of medical research I realize that I am going to speak for that. But I do believe that medical science has a rather special position amongst the sciences.

No matter how you look at progress in other fields, the disadvantages of science have been colossal. I do not speak only of the disadvantages of applying the physical sciences, mathematics, and so on, to problems of war; even the development of what we call a civilization in all its aspects always has destroyed something in nature. It also takes away certain inherent values of life, perhaps by substituting more efficient but, in a way, cheaper and more mechanized values.

Only medicine does not have these disadvantages; it has not created anything which we regret. We have overcome the major epidemics by use of antibiotics. We have overcome enormous sufferings of mankind resulting from nutritional deficiencies by the study of vitamins, amongst others. There are still a few major diseases—such as cancer and aging—against which we are almost powerless. We can do very little about stress diseases, such as cardio-vascular damage.

I think that if Canada could somehow through a wise and moderate degree of centralization, shift the talent and money we have into these areas, we would achieve very much, not only for science but also for national prestige and for goodwill. One does not easily attack a nation which is useful to everyone; Switzerland has exemplified this throughout quite a few centuries. I find it very difficult to imagine that Canada will ever be able successfully to develop its military machinery of defence against its two very powerful neighbours—the United States on the one hand, and the Soviet Union on the other—should they ever decide to attack us. However, we might create a situation where it would not be desirable for anyone to attack. That a nation has developed an extremely valuable and constructive effort in science, and particularly in medicine, constitutes a potent defence mechanism in itself.

You may consider it a Utopian idea to put medical science almost on the level of a nationally planned economy, to lift it into the centre of National interest. Perhaps I am dreaming, and, in any event, I did point out my limitations at the outset; but, nevertheless, it does not seem Utopian to me.

I can imagine that this plan would also be quite profitable to heavy industry through the development of scientific machinery which is very useful to us now, such as the electron microscope, ultracentrifuges and computers or to the pharmaceutical industry. Switzerland concentrates efficiently on its pharmaceutical industry; this helps Swiss science tremendously and, in return, science helps the industry. I think that under these conditions, a well-planned effort could mean a great deal.

I believe that a national aim which really creates enthusiasm would provide one of the most efficient ways of consolidating the nation's different points of view. There is nothing like having a common enemy if you want to create unity in a nation; in this case the common enemy would be disease.

The Chairman: This is just a starting point, I am sure, and all of us will want to ask questions of you, not only as to your views on science policy in general but also as to your own experience as a scientist. It is all very well to try to develop a general framework, but we must never forget the researcher and the scientist at the other end, who is the beneficiary and, perhaps, also the victim of science policy. I am sure that you have much more to tell us about your own experience as a scientist, and your own career, at a time when governments were not really after you to give you grants and assistance. I am thinking of the time when you were more or less on your own.

Dr. Selye: Of course money is one of the daily worries of a scientist. I did not speak of the financial aspects in my opening statement because I thought everybody would mention them. However, there is no question but that science would profit from the availability of more money. The question is how to get it.

I should point out that in my own case throughout the many years I have been teaching in Canada, first at McGill and then at the University of Montreal, I cannot really say that I did not have enough money to do what I wanted. That was not my trouble. My trouble was security. I never had, and I do not have now, a budget for the next year. This has been a very serious handicap, because so much of my energy has gone into trying to figure out ways and means of ensuring next year's budget. One has to write application after application. One has very often to make personal visits and have discussions with people. Even then the money is usually provided on a one year basis. Some foundations may give you a five- or even a seven-year grant, and when one runs out, another one starts. But the fact remains that the entire budget for the next year has never, throughout my life, been guaranteed. As a consequence of this, I think a very large portion of my energy has been spent in an occupation for which I was not trained, at which I am not good, and one that does not interest me, namely that of figuring out how to obtain funds.

It would have cost my various sponsors—the American Government which sponsored us the most, the Canadian Government, and the private donors—no more to give me security. I think it would be a tremendous step if a centralized organization were set up to look after such things.

The Chairman: Thank you very much. I think Senator Phillips has a few questions to ask you.

Senator Phillips (Prince): Mr. Chairman, when Dr. Selye was mentioning contralization I was impressed by the fact that a number of his remarks seemed to be along the lines of some of the recommendations of the Glassco Commission. Then, when he went on to mention security and the amount of time he spent preparing next year's budget—a field in which he said he was not qualified—I was reminded of the remarks I made in supporting your motion, where I said that I had heard complaints from civil servants dealing in research that they had to spend too much of their time preparing next year's budget. It was mentioned to me that that situation would be aggravated when the recommendations of the Glassco Commission were implemented, and there would be more centralization.

I wonder, Dr. Selye, if you would care to comment on that?

Dr. Selye: Well, I do not know exactly in what sense you want me to comment on it.

Senator Phillips (Prince): One of the complaints I heard was that centralization in this case seemed to aggravate the situation with respect to the preparation of budgets.

Dr. Selye: Not having very much experience in this field, I do not know what to suggest in respect to it. I know that the problem lies here, but I do not think I can make any useful recommendation. It is my opinion that the possibility of receiving grants from various sources provides insurance for the scientist nowadays. If a scientist has a good project then he is almost certain to get something from one source or another. On the other hand, this is precisely the situation which takes up so much of his time, because he has to explore all the possibilities before he can be sure of next year's budget.

Senator Phillips (Prince): You mentioned, Dr. Selye, centralized medical research, and this raised the question in my mind as to where the type of centralyzed organization you picture would be?

Dr. Selye: Here again I think several possibilities exist. It could be done under a ministry of science or under existing bodies such as the National Research Council or the Medical Research Council. I do not think that it makes very much difference, as long as the program is well executed. It can be done in various ways, but always in close consultation with the various scientists who are going to profit from this centralization, and who should point out to the organizing body were the real needs are.

Senator Phillips (Prince): Mr. Chairman, later on I should like to hear a bit more from Dr. Selye about his research, particularly that in the field of stress, but I think I should allow the other members of the committee to ask some questions on this matter of centralization.

The Chairman: Yes. Before we go into this, Dr. Selye I should like to put to you a question. If you were a centralist, and if you were put in charge of the research program in the field of medicine, how would you, from your own experience, define the priorities in that research field?

Dr. Selye: I would do that by looking at past successes. I think the best place to invest is where we are already strong. In order to obtain the best advice as to where these areas are I think we should turn to the nation's most recognized scientists, and take the average, so to speak, of their opinions.

The Chairman: But, in your own view now, what would be these areas?

Dr. Selye: Well, I would say that Canada has a strong tradition in the field of endocrinology. Ever since Sir Frederick Banting discovered insulin Canadian endocrinology has been recognized as absolutely first rate. Then, my own chief, Professor Collip made another major contribution with the discovery of the parathyroid hormone.

Quite recently, Dr. Copp of British Columbia discovered a new hormone produced by the thyro-parathyroid apparatus, which also acts on calcium metabolism and thereby he added a great deal to Canadian endocrinology.

I think that you can go to any country in the world, and find that these Canadian discoveries are recognized as first rate.

Dr. Jacques Genest at the University of Montreal, with his work on a hormone called aldosterone has achieved an international reputation; therefore, this would be an excellent place to start and try to develop this field. On the nervous system there is Dr. Penfield's research and that of Drs. Jasper and Cordeau at the University of Montreal. This is another example of a field in which Canada could achieve excellence. There are other more limited areas, limited in the sense that not so many people work in them. Dr. Murray Barr discovered the so-called sex chromosome, thereby making a very great internationally recognized contribution.

I think that a committee consisting largely of non-medical people can appraise a scientist's achievements best on the basis of how his peers judge him. The names I have just mentioned are internationally recognized, and if you ask other scientists, no matter whence they come, they also would undoubtedly recognize these accomplishments as particularly worth-while.

The Chairman: How are we doing at present in the field of cancer research in Canada?

Dr. Selye: A great deal of cancer research is being performed in Canada; but here again, you have to realize that even if one is a physician, and in my case a research physician, one's competence is rather limited. I would prefer to comment on things I know well. Not being that well versed in cancer research, I am not aware of any outstanding Canadian contribution equal to the ones in other fields which I just mentioned.

I personally would very much like to see further development in stress research. Here again, I have to qualify my judgment in a sense.

The Chairman: On the contrary.

Dr. Selye: I have spent 30 years on it and have therefore become quite fond of it. One advantage of stress research at the present time is its timeliness: Because we live in stressful times, stress has a great many implications in our everyday life. It concerns so many diseases about which modern progress has taught us so little that, to my mind, it deserves study.

The Chairman: I think Senator Phillips will want to come back to this later on during the discussion, but as I did this morning I will start from the left. I have a new leftist.

Senator Thompson: First I would like to say that I concur completely with your point of view on specializing in excellence, particularly in the field of medicine.

Perhaps I could raise this with you. I sometimes wonder how nations decide what kind of values get prestige. I am thinking of how the United States and Russia arrived at the idea that they could bring national prestige by being the first to get into space or on the moon. I wonder if you have any ideas on how we can develop a feeling that in terms of our nation we want medical research to be our means of being established in the international community. It is early perhaps to say that, but how do you go about it and how do you set this as our standard?

Dr. Selye: You mean how could you convince the public that this is a good national aim? Is that the question?

Senator Thompson: Yes.

Dr. Selye: That would depend upon methods of propaganda. One has to have adult education along these lines. It is difficult for me to see that our citizens would not accept as equal in importance to space research accomplishments, such as, for example, the cure of cancer or the cure of cardiac accidents. I do not think this should be considered as a Utopian idea. If somebody had said years ago that you could transplant the heart of one person into the body of another, this would have been considered equally as Utopian. Similarly, before penicillin, one would not have thought it possible to have antibiotics which could wipe out a disease. I do not think it less likely that we can find a cure for cancer or cardiac accidents. If it is properly presented to the public I think it would be accepted.

Senator Thompson: You say a considerable amount of your time has to be spent on, I presume, two things, first talking to the public either through books or lectures, and secondly raising money. This seems to be a problem that all heads of departments of any kind have in respect of research. Have you any solution to this? If you had enough money I guess you would not need to do it. Can you see any other approach to it?

Dr. Selye: If we had a centralized policy we could, on the basis of the principles which we have just discussed, choose the special fields. After consultation with people who have international reputation, we could then select a certain number of institutions to be subsidized by the central agency, say by the government, on a permanent basis. This would eliminate the scientist's having continuously to write reports or go begging to various people.

A question which may be pertinent and which very often arises is how one can justly distribute money to scientists in the first place. The writing of applications is not a very good indicator. At the present time, as I have tried to point out in my book, the accepted procedure, both here, in the United States and in most other nations (in France for example) is first to write an application in which you describe precisely what you want to do, what you intend to discover, how you want to do it and how much it will cost. This is examined and a decision is taken. I think that this procedure is full of loopholes and errors which ought to be pointed out.

First of all, there is absolutely no relationship between the ability of a person to get a grant and his ability to solve a scientific problem. Entirely different talents are needed to sell an idea to a grant-giving body on the one hand and to solve a problem in the laboratory on the other. They have absolutely nothing to do with each other. There are people who have excellent "grantsmanship". Because they practise it all the time, they do not do any research, but they know exactly what every grant-giving body likes to hear. That is the first point.

The second point is that the distribution of funds by other procedures is, it is said, very difficult, because the granting bodies say, "How are we going to subsidize somebody if he does not tell us what he wants to do with the money?" This is erroneous. You judge by past accomplishment, just as I would like to see Canada pick its areas of special interest by past accomplishment. We should not start something entirely new, but develop an area where we already have at least something to show.

In the same way, a man graduating from medical school and starting medical research cannot be judged by past accomplishments because he has not yet done any research. He has to start somewhere, but although he cannot give a report on past research, he can at least get recommendations from his former professors. Thus, he can receive a small award so that he can prove himself, and the next year he will be judged on his accomplishments. Gradually he will have a few publications to show and on this basis a decision can be taken as to his merit as a scientist. There should be a special board or committee to follow the work of these young investigators. Thus, one can keep a man supplied with funds from year to year, not on the basis of what he has promised to do but on the basis of what he has actually done. I think it highly unlikely that really new ideas can be subsidized by the old method, because one of the greatest fallacies of this procedure is that, if you know how to write a report on what you are going do do, stating exactly what you want to discover, then your work is not really new. By definition it is not new because if you can plan it, there are already so many precedents for what you want to work out, that yours is the logical course of action. Consequently, it is not a really original discovery. Truly original discoveries are never made that way.

I doubt that Fleming could have obtained a grant for the discovery of penicillin on that basis because he could not have said, "I propose to have an accident in a culture so that it will be spoiled by a mould falling on it; and I propose to recognize the possibility of extracting an antibiotic from this mould."

You cannot recognize such a possibility in advance. If you find that one hydroxyl put into a compound is not enough to improve it, you try two hydroxyls. You can employ more economical methods for cheaper production of a drug, or for its better use. Those are not great steps forward. You will never get very far that way.

To my mind, you can only evaluate a man's worth efficiently by taking into consideration his whole past, and particularly his immediate past, because he may have deteriorated in two ways. In time, a person may have developed into a bureaucrat or may be getting too old. But by taking into account his last two or three years, this would be a relatively just system. Another great handicap in our present methods—it should have been mentioned before—could be avoided, namely the pressure of publishing.

I am sure that, as regards publications, almost everyone finds himself in the same position as I do. Being subsidized from twenty different sources, we are under compulsion to publish every little thing we find in order to justify renewal of a grant. This is not good for science for it only serves to increase the already excessive literature. How to handle literature constitutes a problem in itself, Mr. Chairman, which perhaps we should discuss separately.

Consequently, the scientist is obliged to spend his time on writing up minor, trifling things, instead of working on major problems and publishing his findings only after something really worthwile has turned up.

Senator Thompson: One of the criticisms I have heard as to state grants for medical research, is that the people who are assessing whether grants should go to medical research are more administrative in medicine than actual scientists. I am wondering, for example, if you serve on a committee that decides what kind of grant should be given to different research, or would you do this across the country? The practising scientists are probably too big to take time off. Or would be excited by their own development, to take time off to administer the granting of funds?

Dr. Selye: I think this point is extremely well taken, because I think most scientists would be unwilling to do this. It is an egotistic attitude, if you wish. But you have to look at these things as they are.

Most really efficient and successful scientists are extremely unwilling to serve on committees of any kind. Others are not very capable of judging.

An effective solution would be to circulate the recommendations among various scientists and get their opinions without asking them to travel to a central meeting place and lose a great deal of time in so doing. I think most of them would be very cooperative.

I do not serve on any committee which distributes grants, but I do very often give expert opinion on specific applications, mostly from the United States National Institutes of Health, in cases where a committee wants to know whether such and such a project should be subsidized. I do it conscientiously and I do it gladly, since it does not take that much time. But travelling to a central place, to Ottawa or Washington, and spending a day there, also means losing another day in travelling back and forth and this would be too disruptive if it happened frequently.

Senator Thompson: Thank you very much.

Senator Desruisseaux: Dr. Selye, at the beginning of your presentation you mentioned, if I read you correctly, that we should try to retain experts in a few fields. In your view, what would those fields be, that we should be most concerned about—in your view?

Dr. Selye: As I tried to point out, the fields which come to my mind first are endocrinology and neurology. Perhaps, under the general heading of stress research, we could also examine such maladies as cardiovascular diseases, acute heart accidents, etc., resulting from stress, and even the problem of aging, which is very closely related to stress and the wear and tear of life.

Senator Desruisseaux: Would you, for example, share the view that has been expressed on mental retardation, that about three per cent of the population is affected by it somehow?

Dr. Selye: I am not competent to speak on that.

Senator Desruisseaux: I think you also mentioned that it would be good to have a national aim. In your view, what would be the ideal aim in Canada, do you feel?

Dr. Selye: Certainly that is a very big question.

Senator Desruisseaux: I know.

The Chairman: If you answer that adequately, we will write our report tonight.

Dr. Selye: I cannot help thinking that I must always disqualify myself before making a statement, in order to make it more as a private citizen than as an official. Personally I think that medical research would be an excellent thing and I believe it can be developed to the stature of a national aim, if it is looked upon as I tried to suggest. I would point out that, if we really wish to set about this task seriously, we have first of all to import competent people because we ourselves do not have sufficient numbers. It takes too long to train young men and we cannot develop them without suitable teachers. So, from the outset, we must recognize the fact that in order to bolster research in a serious way, we have to encourage the immigration of first-rate people. Each one could lead a research center. You need only one very outstanding master in a school to attract students and assistants.

I have often discussed the question of a so-called "super university" or post-graduate university, dealing on a very high level only with post graduate teaching and research. This could be envisaged as one of the national aims.

Furthermore, a parallel development in industries, dealing with the health sciences, from the pharmaceutical industry to those which produce scientific instruments, etc., would be interesting for the economical aspects of such a plan.

I certainly would not think that any one planned objective should become the sole one. Naturally, we have the wheat of the prairies and we do not want to give up our mines or our natural riches. But as a plan which does not depend on the soil, which man and not nature can give to the country, medical research would be an attractive one.

Senator Desruisseaux: If I may impose on you again, Doctor, you have a very wonderful biography and you have travelled so widely and acquired so much experience all over the world, I would be very tempted to ask your views as to how Canada presently compares in experimental medicine with other countries that you have seen or are acquainted with.

Dr. Selye: I think Canada compares extremely favourably. Considering our population and the number of medical schools we have, we can show results of equal importance to almost any other country. There are certain fields outside of medicine for which we cannot make the same statement. Among other nations, which are really in the forefront, I think the United States should be mentioned first in the health sciences. The United Kingdom would come very soon after that, and then France—and I think that Canada comes pretty well on the same level as the last mentioned.

Senator Carter: Dr. Selye, if I understand you correctly, in developing a program of medical research for Canada, you would begin by concentrating on those fields where we already have outstanding men who have already done original and outstanding work.

Dr. Selye: Yes.

Senator Carter: If I understand you correctly, this would be only the beginning, because, obviously, those would be the chosen few but there would be other, perhaps not so well known, people doing original work.

Dr. Selye: Quite.

Senator Carter: And those might in time become famous and the program would be expanded in that way. In your own research you have pioneered the effects of stress on human health. In following along your own line of research you must have passed many avenues where you would like to have gone off and explored, and I presume that, if you were to find the mechanics of developing our program, it would progress along such lines that the people already doing outstanding work would map out a program of further research along the avenues that appealed to them, but, because they would be concentrating on one objective they would not feel it desirable to go off and explore the by-ways. Would that be a correct assumption?

Dr. Selye: If I understand you, senator, you are saying that if we concentrated on certain fields we would have less inducement to explore other fields. Is that what you mean?

Senator Carter: No. In the fields that you are already exploring, in your own personal experience in your research on stress, are there any avenues that you bypassed along the way but which you would have liked to digress on and explore as sidelines?

Dr. Selye: Oh, yes, indeed. For example, there are three major avenues of stress research which are not immediately connected with it and not generally considered under that heading, but which, to my mind, are extremely important. They represent some of the most important medical problems of our time. These are cardiovascular disease, inflammation and aging.

Let me comment on these one by one to show how they are related to stress. Stress is essentially the wear and tear on the body, the "use" of our tissues, be it for resisting disease or just for playing a game of tennis. Or again, it may be the stimulus that the body receives by way of excitement—learning very sad or very pleasant news. Whatever makes the body work harder has general effects which we call stress effects.

Each situation, each disease-producing agent, has its own specific effects. We get typhoid from typhoid bacilli; a quick pulse from running too much. These are specific effects but, in addition, there is a general "use," or we could say, a wear and tear. It is exactly the same as in a physical system: in this building, electricity can be used to give light, or heat, or to cool, to make a bell ring or to sound an alarm. These are completely different specific effects, but all consume electrical energy.

Well, stress consumes vital energy; it can be easily understood, if we say that it is that which consumes energy. The layman generally conceives of stress as hitting the whole body. For example, I am under stress when I am tired or sick. But from a purely medical point of view there is such a thing as local stress. If I burn myself on the hand, just a small, local area is affected; but even so, there is a considerable local stress effect. A lot of energy is used up by the body's repair mechanism. The most apparent effect of this local stress is inflammation.

I would say that inflammation is involved in the majority of diseases. Whether it is tuberculosis, cancer or tonsillitis, some inflammation is always present. However, the study of inflammation is of less concern to the public and more difficult to understand because it is more remote from daily thinking than the idea of stress as it concerns the whole body. It is, however, at least of equal importance.

Stress is also related to cancer because stress localized at one point may cause cancer. This is a most important area in which I would very much like to have involved myself, had I had the financial facilities.

Another area I mentioned is cardiovascular disease. Most of you know that a person who is predisposed for it by age or by certain pre-existing arteriosclerosis, can suddenly collapse from a cardiac accident due to stress. It may be a mental stress, that is, a very traumatic, exciting experience, or it may be a physical stress such as excessive muscular exercise to which the person is not accustomed. But in either case the result is the same: a heart accident.

By studying animals we have already learned an enormous amount about the basis of cardiac infarct, of its mechanism, and of ways to prevent it. This would be one of the major areas where national efforts could lead to something that really earns international recognition for the solution of an important problem.

Since so much has been written about cardiac transplants, perhaps it would be pertinent to point out here that, although these are great accomplishments in surgery, they are not and can never become the solution to the problem of cardiac disease. Even if we could overcome the rejection phenomena, cover the financial cost of doing such operations and solve the problem of storing organs by keeping them on ice—in a bank, so to speak—it is quite inconceivable that a disease which annually causes millions of deaths could be handled by such a complicated procedure.

On the other hand, laboratory observations show every day that one can prevent or at least reduce cardiac deaths in experimental animals by chemical means. If we could develop a pill, a remedy which could be taken by mouth as a preventive measure, I think this would be much more interesting on a national basis. Also, we have to take into consideration that animal experimentation has already shown that such infarcts can be prevented by orally administered drugs. Therefore, it is only a matter of further developing this procedure and applying it to clinical problems.

And finally I mentioned aging.

The Chairman: That is the Senate's problem.

Dr. Selye: I think aging is not only the Senate's problem; it is a general problem.

Senator Carter: It does not apply to the Senate.

Senator Hays: We have got lots of money for research on that. Don't worry about it.

Dr. Selye: You have no monopoly on aging.

The Chairman: You will have a ten-year budget.

Dr. Selye: You may or may not suffer from this or that disease, but if you live long enough, you will suffer from aging. Therefore, it is a very important problem. Here again, if you ask for daring new approaches to problems, for originality, you should be warned against the inclinition we all have of regarding aging simply as a natural phenomenon. There is no proof for this assumption. First of all, there are many instances of people who have lived well over 100 years, and some perhaps less well authenticated cases of people living past 160. At any rate, we have no proof that there is a limit to the life span, that a fixed "life span" is absolutely essential. Just how long you could prolong life is still a question.

In our laboratory, for example, and growing out of stress research, we have done the following: we have taken a two-month old rat and have made him look, within six weeks, as if he were close to death from aging. He will have arteriosclerosis, senile tooth decay, and kyphosis; he will lose his hair and have cataracts. How can you tell whether a person is old or not except by his looks? There are two types of age, the chronological and the biological age. Chronological age is based on how many years a person has lived since his birth. There is no argument here. But this is not the important type of aging; rather the important aging is determined by how "used" your body really is. There are persons whose chronological age is 40 and whose biological age is 50 or 55. If young rats treated by chemical means look old, we have to suspect that they are aged prematurely. There are premature aging conditions in human beings as well, which are quite pathological. A child of 15 can look like a senile person. This is called progeria, a phenomenon which occurs spontaneously with the result that there are young people whose biological and chronological ages are not the same by far.

The Chairman: Can you do the opposite?

Dr. Selye: No, but we can help to prevent progeria, and this is a first step. We can give two rats the aging treatment, then apply to one of them an anti-aging treatment and this one will not age. But to apply this technique to human beings is quite another matter. Specialists in this field should not be too optimistic about how quickly basic research and development can be applied to clinical problems. We have not yet been able to revert natural senility changes in human beings. But at least we have taken the first step.

The Chairman: But in these problem areas where you were not able during your career, at least up to now, to devote enough time, were you in a position to develop a system or is the letter to "Dear John" just a mere regret?

Dr. Selye: No, the letter to "Dear John" is an expression of regret in another sense. With your permission I should like to say a few words about that. But first I will answer your specific question. There are, at the present time, 16 professors all in other departments at the University of Montreal who are former students of mine. I do not mean to say they were all merely undergraduate students at the medical school, but most of them have been there for three years, they have their PhD degrees and completed their theses under my direction. Throughout the world, I have 24 full professors in medical chairs who are also former students of mine. In this way, if I should lose out in the study against the process of aging, there will still be research going on in this field.

Now to answer to the second question referring to my letter to "Dear John" in *From Dream to Discovery*. This concerns a problem which might also be pertinent to the interests of this committee in that I do regret very much the tendency in modern medical research to do what is termed reductionism. That is to say, living systems are reduced to smaller and smaller bits and the smallest possible particles one can possibly see are looked at and examined. Some of the greatest discoveries in medical research are the product of what we call molecular biology, and that involves a reductionistic attitude. I do not think that this should be discouraged; on the contrary, I think it should be very much encouraged. Nonetheless, it seems regrettable that the old method of the holistic approach, that is the approach to man as a whole or even to a kidney as a whole and not just to one molecule of the kidney should not be abandoned. This type of research is threatened to become almost obsolete even in my own day. The change came gradually during my own lifetime because when I was a medical student, this was the usual way of doing biological research in medicine and the other life sciences. When dealing with disease in an animal, one looked at the effect of the disease on the whole animal. But nowadays the tendency is to take an animal or a diseased organ, to cut it up into the finest possible sections and look at it through an electron-microscope. Then, not even one whole cell can be seen because the magnification is so enormous. The result is that you can only see one minute particle. The trouble with this reductionistic tendency is that one loses perspective. I am convinced that the really great and new overall discoveries about life and the phenomena of life cannot be made in this way. New diseases are being discovered even today but never by looking at just one cell. The teaching of correlative research is very important, that is, research where one sees what is happening here and then what is happening there, and finally the two are put together. This would be a beautiful field to develop in Canada. It is badly neglected elsewhere.

Senator Carter: In this correlative research as in any research there must be a tremendous amount of reading involved. Have you been able to utilize computers and banks of computers to solve this problem?

Dr. Selye: Speaking for myself, I have not, but I think computers have done very much for other people. My subjects are such that they do not call for the use of computers; but, computers in medical research and other fields are most useful.

I should say that I have used computers for statistical work on minor details but not for making discoveries, so to speak. That is explicable on the basis of my previous remarks about planned and unplanned research. The greatest discoveries are made by accident, but you have to prepare a man so that he can profit from the accident. Such non-planned research is therefore the most original, and since the resulting discoveries cannot be calculated, the computer has very little place in it.

I did get very close to computerization in another area which I mentioned before, the "literature explosion", as we call it. There is an enormous amount of data which we cannot digest. I don't know to what extent you are familiar with these problems. But according to various experts in the field, 90 per cent of all the scientists who have ever lived are alive today. That is to say that, if science produces 100 units of knowledge, 90 of those units were produced during our lifetime; you can imagine the amount of literature that this gives rise to. In our own institute, we work mostly on correlation and perhaps it is therefore not a good example because we have more than the average amount of literature to cover—but we are adding new publications to our library at the rate of 500 to 700 articles every week. That is worth a bit of thinking about. Five to 700 scientific articles must be digested and screened every week of the year by our staff, in order to give us the information we need for our research. To do this we maintain a large department, and if one considers all accomplishments of our Institute, I think, improvements in medical library science is one of them.

I have a library which was founded in 1848. It was started as an endocrinology library, but over four generations it was developed according to the interests of whoever owned it. Now it is the largest stress research library in the world. We have also developed a special system of information retrieval, and filing, which is not computerized, but based on a special shorthand system. This system is being used in many other libraries. In fact, Rutger's University held a Congress to investigate our system in the United States; medical librarians came to study and, perhaps, to improve it. I can imagine very few areas in which science could be of greater service to humanity than that of solving the problems of how to cope with the literature we already have.

Senator Carter: Just for clarification, those 16 professors you refer to in the University of Montreal, are they carrying out, under your supervision, a planned program of research in those fields?

Dr. Selye: They are working in different departments all over the medical school. They were taught by me; they obtained their Ph.D. degree at my Institute; but now they are in other departments, physiology or anatomy, for instance.

Senator Carter: Is there any planned program of research?

Dr. Selye: Their work is not co-ordinated. Some of them happen to be involved in subjects similar to those they started with me, but not all of them. Even if they work on subjects related to mine, they do so completely independently; there is no correlation.

The Chairman: Senator McGrand has a few questions to ask, I understand.

Senator McGrand: Yes, Mr. Chairman. Pardon me for asking a question out of turn.

There has been a good deal of discussion and questions asked as to what area of medicine you would prefer to concentrate on here in Canada in order to give Canadians prestige. I do not think that Canadian research in medicine should be conducted in any way that would give prestige to Canada or presstige to a few individuals, but that the purpose should be to improve the physical and mental health of most Canadians. So, that leads me to this question: What should be, in your opinion, the grand objective of medicine —bodies that are free of physical disease, or human beings able to live in an environment in the world over which they have very little control? I ask that because I just cannot separate health and medicine from psychology and sociology.

Dr. Selye: Firstly, I would like to say that I fully agree that the primary objective of medicine is to treat the sick and to prevent disease. I did not make particular mention of this point because it seemed self-evident; I concentrated more on others which are not so self-evident. Concurrent with improving health, medical research would give prestige to the Nation and at the same time would give an interesting and unifying purpose; but I fully agree with you that the first objective, of course, is to keep the population healthy.

It is also perfectly true that the social aspects cannot be divorced from the purely medical ones. This is especially evident in my field of stress research, because social pressures are the most common stress-producing agents. They are, as we say in the jargon, the "stressor" agents of our civilization to which the population is exposed. Stress diseases are so much more common in human beings than in animals because we have a highly developed nervous system which is much more sensitive to personal problems which worry us but do not worry animals.

If we develop the health sciences parallel to the social sciences—at least in the field where the latter touch upon psychiatry and psychology—then great benefits will automatically follow.

Senator McGrand: Research is not new. It has been going on for a long time. It is just that in this century research has reached its present momentum. Yet, in spite of all the additional knowledge that we have obtained through our research, there are more people today occupying beds in hospitals and suffering from disease, and more people in mental institutions, and more people in penal institutions, than at any time in our history. It seems to me that there must be something done to redirect medical research, and to keep it in line with its full objective.

Dr. Selye: Well, that is what we are talking about. We are trying to formulate a policy as to how this should be done. It is a fact that more people are in hospitals now than ever before, but it is also a fact that more people stay alive longer today than they did before. At the beginning of the century, if I recall correctly the average life span was around 40 years, and now it is 70 years. So, we have a very much larger population in the age group where hospitalization is more common.

With respect to mental disease we have the same situation. The fact is that we live in a society which has many stress-producing factors in its structure. Mental disease is one of the classical diseases of stress—at least, certain types of mental disease. On the other hand, because of the discovery of phenothyazine derivatives and particularly chlorpromazine—better known to the general public—a very large proportion of the people who would be permanently hospitalized for mental illness are now ambulant patients. They are perhaps not definitely cured, but the effects of their disease are greatly ameliorated and many of them are able to live useful lives.

Senator McGrand: Mental illness is on the increase rather than on the decline.

Dr. Selye: Yes, it is on the increase, but I think that despite this fact greater numbers of those suffering from it are now well controlled.

Senator McGrand: Coming back to the subject of research, I remember hearing Dr. Paul White discuss in this building the development of coronary and heart disease, as we know it, and also the probable causes, and so on. He emphasized that we are trying to make children today grow taller than they did at the turn of the century, and this is done largely by giving them increased amounts of milk and vitamins. He had a feeling that perhaps in the diet of these children lay the early foundation of future heart disease. Of course, there has always been the question of whether milk is a proper fluid for adults to drink. Adult human beings seem to be the only animals that drink milk after the weaning age. It seems to me that there could be worked out a program of research to prove once and for all whether heart disease and arterial disease is caused by animal fats, and that sort of thing. I do not think it would be hard. It does not require a lot of original research. It requires merely frequent and complete laboratory tests of a thousand or more people. Yet, in spite of the fact that this thing has been going on for years and years, and a certain amount of knowledge has been gained about it, we are still as far away from a knowledge of the causes as we were 25 years ago.

Dr. Selye: I am very glad you brought that up, because it is one of the problems that centralized leadership could help with by directing the research.

In the experiments on heart accidents, which I have mentioned before, we have in fact studied in animals the importance of dietary factors, including the effects of fats, sugars, various salts, and so forth. Such animal studies are extremely important, and have to be made before one can undertake similar studies on human beings. In animals you have a more controllable situation. These animals are all of the same species, the same age, and the same sex; furthermore, they can be placed in a situation in which they normally would develop a fatal heart accident. Then only one dietary factor is changed. That is a very difficult thing to do with a human population. All available statistics are still full of loopholes, because every person is different. For example, the treatment that I receive cannot be compared with the treatment you receive, because we are not exactly the same. Here, a centralized agency would be of great help in applying to patients the results obtained along these lines, where each factor in the diet can be systematically controlled.

In the United Kingdom there is a committee dealing with drugs—I do not recall its official name—which is in charge of testing different drugs on a large scale, and statistically analyzes the results. If we had a similar sort of setup to apply the results obtained from animal experiments to the human population, a great deal could be accomplished. Such a central organization, headed by absolutely reliable statisticians and other experts in his field, could provide much information.

Then there are our double-blind studies, as we call them, in pharmacology, comprised of a control patient and an experimental patient. For example, in the case of a cardiac infarct one would take two people of approximately the same age, the same sex, and the same body weight, and so on. The probability of their having a cardiac infarct within the next year has already been established. One would be given the recommended drug treatment, and the other a placebo—unknown to him he would not be getting the drug. Only the central committee would know what was being given to each patient, and would have the key as to whether he received the drug or the placebo. In other words, the committee would supervise the study.

Many a good drug has not been used because the particular scientist who first discovered it had no clinical facilities to use it. He just published his findings in a journal, and 20 years may have passed by before clinicians finally picked it up.

I had a similar experience myself: I accidentally observed that anaesthesia—deep surgical anaesthesia—can be produced with a hormone. That was the first time a hormone was used to anaesthetize experimental animals. It took something like twelve years before this was ever used in man; I mentioned it to several pharmaceutical companies, and the reply was: "Well, we have ether".

Senator McGrand: I did not hear your, doctor. Did you say that you had induced anaesthesia . . .

Dr. Selye: Yes, put animals to sleep with a hormone—an endocrine substance. That was the first time it was done using a natural substance like this.

Senator McGrand: What hormone was it? I am interested, because I am a physician myself.

Dr. Selye: I used progesterone. I offered this for clinical purposes to pharmaceutical companies because I thought they would be the most likely ones to test it for me. Nobody wanted to touch it because they said they already had good anaesthetics. Besides that, it would have been prohibitively expensive, as large amounts of progesterone are needed.

Senator McGrand: You said some time ago that most of the discoveries were the result of accident, and that you came on to this by a kind of accident. It seems to me that with a co-ordinated well founded research program it should not be as hit or miss as it evidently is. It seems unreal that the best discoveries should be found by accident. I do not think that in the field of chemical engineering discoveries are made by accident; they are the logical result of experiment. If there were properly co-ordinated, oriented medical research this question of error would not arise as frequently as it does. Evidently a lot of experimentation is just thrown away, wasted. It is only the occasional things that you find are worth while by accident. Is that right?

Dr. Selye: I think that is perfectly correct, but we must specify what we consider a true discovery. In technology, for example, planned research is indispensable. Establishing the best yield and the cheapest way of synthesizing cortisone is a technological problem. We already know that cortisone exists and has certain applications. We do not have to discover this. The question is how to make it in the cheapest way with methods which have yielded beneficial resuls with other compounds of a similar nature. The only way to do it is through logical planning; you could never rely on accident. But you cannot plan to discover that cortisone has beneficial effects on inflammation, because nobody ever thought of it before.

I think you will find that most of the outstanding, really totally new discoveries are accidents. I cannot take credit for saying this first, because many people have said it before. One of the most illustrious was Claude Bernard, who pointed out: "*Les grandes découvertes sont dues à la chance, mais il faut avoir un esprit préparé pour profiter de la chance.*" Great discoveries are due to accident, but you have to have a mind prepared to profit from accident.

My recommendation is that research in technological engineering should be planned; it should, as you point out, be a logical sequence of events which leads to the solution of the problem. It is the same in medicine. When you set up a project you cannot just sit down and hope lucky. You have to have your everyday bread and butter, so to speak, a program which is well planned and well organized to keep you usefully occupied, but I maintain that the really great discoveries will not come along these lines. The really great contributions will be totally new and unexpected things. In my book I distinguish very sharply between "problem finders" and "problem solvers'." With the technique of planned observation you can solve a problem—indeed, it is only with the technique of planned research projects that you can solve it—but you cannot discover a new problem because you cannot know where it is.

For example, the following is a minor discovery and I do not mention it because it is so remarkable but because I like to report from my own experience. Several years ago I was experimenting with progesterone, a female sex hormone which happened to have been discovered at that time. I was doing the most pedestrian type of research you could possibly do, by trying to find out what this hormone—which somebody else had discovered—would do if we gave too much of it. That is the simplest plan you can have. I injected the substance and the animals fell asleep. Nobody in the world could have foreseen they would fall asleep, nobody could have given this hormone to find out whether this would happen. It took about 15 years before the Pfizer Co. put such compounds on the market.

Senator McGrand: It took 15 years to follow up?

Dr. Selye: Yes.

Senator McGrand: That is just what I mean. With a well co-ordinated plan it should not take 15 years.

Dr. Selye: Exactly. I could not agree more. We can save by following it up, but not in making the original discovery. That is also why a certain amount of freedom has to be given to every original scientist; you have to let him have accidents. Once the accident has happened and has proven useful, how to use it can only be established, as you say, by planned research and by organization.

Senator Lang: I have a proposition to put to you and I should like to ask for your comments on it. Beginning with your thesis that in Canada we should concentrate our research efforts in areas where we may maintain excellence, I think no one would quarrel with you as that affects science, but I think I would accept the proposition with some reservation as applied to medical science, particularly when you have to recognize that unlike the results of research in the nuclear field or in the political sciences, where we can import our knowledge, in a sense the medical profession and medical sciences are interrelated and we cannot import our medical science because of that correlation.

This proposition might, I think, be borne out by the reaction of the medical profession themselves in medical sciences; they are a rather different breed of cat; they rather zealously guard the pre-eminence of their own specialities, I think very rightly so, because the excellence of the profession as a whole depends upon the excellence of its research elements in its component parts. I suggest to you that if your thesis be applied generally to the medical profession and the medical sciences we might experience a very serious attrition in certain areas of medical science which will stem from loss of professional interest initially in that particular speciality, and then finally the inability of that speciality to attract within its ranks the best of the young medical students coming into the field.

I would say philosophically that the medical profession and medical science is a basic component of any social order, and it must be indigenous. Because of that fact funds for medical research must not be arbitrarily directed into certain areas of selected excellence. I would appreciate your comments on that general proposition.

Dr. Selye: First of all I am not sure I understood clearly what your objection is to the importation of excellence.

Senator Lang: We may import knowledge, but knowledge must also in the medical profession, in the medical field, go hand in hand with general professional excellence in the practice of medicine. I do not think we can import general excellence in the practice of medicine.

Dr. Selye: That is perfectly correct. But you only have two choices. Either you concentrate on certain areas or you do not—in which case you try to spread it out on all fields. In my opinion, it is better to have certain peaks, without totally neglecting any area. I feel it desirable to have certain peaks and develop a sort of aristocracy of knowledge. Of course, no nation can support everything to a maximum: it has to delete something comparable with the cost of purchasing other things. This is not going to cause atrophy of other fields. I would not be afraid of that. The presence amongst us of very distinguished people in any one special field would stimulate the spirit of research and interest in research in general, we would very soon find that many an other field develops in a highly cultured atmosphere. This new field would be indigenous.

The Chairman: Is not this the case where you must make a distinction between research and training? You can get training in another country and come back and train other students and give them first class training here, without really having contributed to the advance of knowledge or to research in any basic way.

Dr. Selye: Yes, if we find that in Canada we do not have really good teachers in certain categories in which students want to specialize, they will have to go elsewhere to get this knowledge. That does not mean that you cannot get it at all; you just cannot get it here. As I say, there is no other solution but either to subscribe to good average mediocrity across the board, or to create outstanding monuments of knowledge in certain areas.

Senator Lang: If I might point out, from a practical point of view, this is relatively unobtainable in Canada in the medical profession today. I can give you one example of a proposition we have been working on in the City of Toronto now. This is through the leverage of the health fund and provincial grants, and the control of that by the University of Toronto, to attempt to integrate the various teaching hospitals within the city, into one medical complex, in fact, one hospital, one large teaching hospital. This would mean that the Toronto General Hospital would be open to heart surgery, the Toronto Western Hospital would do kidney transplants, and some other hospital, perhaps St. Michael's, would take on another specialty.

This concept in theory is efficient and probably would produce the highest degree of excellence within those specialties, but the acceptance of that concept by any one of these individual hospitals is practically impossible.

The staff of the Toronto General Hospital would have to say "If the patient is going to have open heart surgery, and he will not be able to have it in our hospital, he will have to go to the Western Hospital"—that is a psychological hurdle the medical profession finds it very difficult to get over.

What I am suggesting is a realistic appraisal of medical science in Canada today would lead me to believe that any attempt at a co-ordinating central body to designate certain areas that would be given specific attention, grantwise, facilitywise or otherwise to do that, is going to create countervailing problems in other professional areas. The overall picture will tend not to bring about the excellence that you suggest but rather a mediocrity across the board which would completely negate the original thesis. I think this is inherent, if my supposition is correct, in an appreciation of the medical profession and medical sciences as differentiated from all the other sciences.

Also, our experience in medicine in Canada has been that our advances, our major breakthroughs, have come by persons working in a place relatively isolated from a community of researchers. It may be this is because we are all thinking of Banting and that sort of history in Canada, but it is probably in the areas with the accident concept that you have brought forward, that we are going to make our medical excellence. I suggest it would not come about by state planning or any centralized planning, in terms of trying to organize the profession and the common science along certain lines.

Dr. Selye: I do not really know, but since you mention Banting as an example, in 1923, he had to go to one of the biggest centers we had at that time, at the University of Toronto, because Kingston did not have proper facilities. The center at Toronto was useful to him, and although it was small, it was the biggest we had.

You are perfectly right in mentioning psychological applications which would no doubt help. It is extremely difficult to co-ordinate medical men and dictate a plan of any kind. But that would be a challenge to any committee. Perhaps such a committee could also consult research scientists and psychologists who would make useful suggestions on how to do it.

Senator Lang: This may not be entirely a question of fees, Doctor.

Dr. Selye: All of this is taken into consideration, but I do know that it can be overcome. We have a very highly specialized institute ourselves and it happens to me all the time that I cannot give a student all he needs and he has to go somewhere else. I am not at all inhibited about it. Right now I have an assistant professor at Harvard learning certain electro-microscopic techniques, which I cannot teach him. It also means that we get many others—more than we send out—who come to learn other techniques in our center. If the hospital, as you mentioned, has to send a patient to another hospital for heart surgery, the second hospital will send its kidney transplants to the first one in exchange. If no hospital has an excellent technique for handling it, then I suggest they should keep their peace.

Senator Thompson: I am interested in your remark where you say you do not know how one can plan for next year. It seems to me strange that if all Canada takes pride in your work, you should not have got sufficient funds to plan for next year. It seems to me that there is a history in all research and in medical science across Canada and if I can I would like to correlate this with another question. You mentioned American funds. I wonder what proportion of those funds for your institute are American; and if they stopped, whether the institute work would stop?

Dr. Selye: This is the crux of the problem. From the beginning the institute was built up almost exclusively on American funds. I left McGill to go to the University of Montreal in 1945. Eighty per cent of our budget at that time came from the United States and the remaining 20 per cent was the total sum of contributions from the University of Montreal, the Medical Research Council—at that time the National Research Council—and all other Canadian resources.

Right now, the American portion is 27 per cent. The decrease started at the beginning of the Vietnam situation. It has become extremely tragic. In fact, for a certain time last autumn we thought that we would have had to close up the institute. Some of you may have read that at the time, they wanted to build me an institute in Texas. At the last moment I managed to save the situation, thanks mainly to a contribution from the Ministry of Health of Quebec, which took action in order to save our Institute by giving me a grant of $172,000—just enough to finish the year and give us a breathing spell. Otherwise I would have had to discharge 34 people from my staff which numbered then approximately 100. To train those 34 people took years. If you have to let them go, you never get them back again. It is impossible to work under those conditions. Right now I must say our situation is still extremely precarious. We overcame that one crisis but we continuously go on living in a situation where I now do not know what my budget will be for the next academic session, which begins in June. Thus no firm commitments can be made to get good first-rate men to stay. You have to give them such assurances that, if they are satisfactory, the money is there to keep them on. Under present circumstances this is extremely difficult.

Senator Phillips (Prince): If I may ask a question, Dr. Selye, what would your total budget be and what percentage comes from various federal organizations such as the Medical Research Council?

Dr. Selye: Well, budgets are not easily put into precise terms for a year, because they overlap. One grant starts at a different time than another. But for the fiscal year 1966-67 we calculated the total budget at $626,000. The University of Montreal's contribution was below $100,000. That is to say, it was less than one-sixth. That included my own salary and that of all permanent staff members. The rest we obtained from various sources. The Medical Research Council gave us $85,000 a year out of a budget of $626,000, which again only helps a little. But in all fairness, I must say that we are getting one of the largest grants; so I cannot complain too much about it. However, the fact remains that all this only covers a small percentage of the total.

The Chairman: But where is the rest coming from?

Dr. Selye: Well, we get funds in little bits from here and there, from private foundations, from industry, and even from West Germany. I think I am the only one in the medical profession getting any money from West Germany. I do not know whether that is a fact, but I have never heard of anybody else getting such an award. We get $60,000 a year for cardiovascular studies from Arzneimittelwerk Fischer, a pharmaceutical company in Western Germany.

Some of our grants are as low as $3,000 a year, and we constantly have to write applications and reports; a very considerable portion of my time goes into purely administrative work, and is therefore wasted as far as science is concerned.

Senator Kinnear: Mr. Chairman, I would like to ask Dr. Selye a question concerning something he said in answer to a question of yours, if I heard correctly. It was to the effect that you could reverse the process of aging from aging to youth, and I think the answer was no, but that you could arrest aging. If you can, why is it not done? And why does it not get through to local medical clinics? It seems to me that the important thing in this world is to keep people young and vigorous and not have them become imbecilic with age, which happens so often.

Senator Phillips (Prince): You are very young, and you have no worry in that regard.

Senator Kinnear: Well, thank you.

Dr. Selye: That is very true, but as I pointed out in regard to hormone anaesthesia, it took about 15 years to interest the clinicians and the pharmaceutical industry in it, although the problem was obviously immediately applicable to clinical medicine.

With the aging problem we are much more in the beginning stages. As I pointed out, we can produce premature aging and we can prevent the progress of that premature aging in animals. We cannot prevent natural aging, not even in animals. At this time it would be premature to apply this procedure to human beings. But in any field we have to take one first step. If we had the facilities, we would first of all attempt the inhibition of natural aging in animals and then apply our findings to human beings.

Incidentally, it is not only a question of money. It is also a question of available talent. The great emphasis which society in general has put on spacemen, as a concept of what is desirable, has directed so many of our most talented young men into the physical sciences that we no longer get the same calibre of young men in our medical schools. Of these, only a very small percentage is either capable or willing to go into basic research.

Therefore, an organized nationwide effort to promote science and medicine would also have to consider very much the problem of public education of young people to give them a stimulus to go into medicine.

It is basically a question of propaganda. All of the writers, from the writers of books to those of newspaper articles, seem to idolize spacemen. The space age is glorified by television. A young boy wants to impress his girl friend and feels she will think highly of him if he goes into this line, because this is the modern thing to do.

If we would put equal emphasis on the value of saving human life—not only by adding years to life but adding life to years, as the Geriatric Society's motto says very correctly—then we could attract a much better type of pupil to our graduate schools. I think Canada has the potential talent.

The Chairman: Perhaps the heart transplant will impress the girl friends now.

Dr. Selye: That may be true; these things are very important. You have to think of it in a human way. Somebody mentioned before the psychological factor in this. Well, the psychological factor must not be neglected. If you create a great public desire to accomplish excellence, that excellence can be found in the muscles of a Roman gladiator or in the intelligence of an Einstein. Whatever impresses girl friends and parents and others, is going to attract young, ambitious minds.

Scientists too are only human. I think a central organization, without trodding on anybody's toes, could do a great deal to develop a consciousness in the nation of the importance of medical research and its cultural and scientific values.

Senator Thompson: Just on the question of salaries, sir, what would be the salary of one of your postgraduate students after his Ph.D. work?

The Chairman: Devoting his time to research?

Senator Thompson: Yes.

Dr. Selye: I am glad you asked that question. Most of my students are MDs, although there are veterinary surgeons and PhDs. Starting with no fellowship of his own—unless he brings one from a foreign country, and that is out of my scope—a young M.D. gets $3,600 a year and $30 per month for each dependent. That is a pitiful sum. So, really, he has to be self-sacrificing in order to accept the position.

Senator Thompson: He would almost come under welfare allowances.

Senator Lang: Would he normally carry on a practice on the side?

Dr. Selye: Never. Nobody under this arrangement is allowed to do anything else but research. He really has to live on that.

Senator Lang: You have a very unique institute, I suggest, doctor.

Dr. Selye: Most of the national foundations give similar amounts to beginners in research, and that is all we can afford. The second year they get somewhat more, but that is what they have to start on; they have to make their decision to take up this career, keeping in mind this very low salary. Curiously, we get candidates for it anyway, but they have too many preoccupations about mere survival to devote themselves wholly to it. It is not a healthy situation.

Senator MacDonald: I wanted to pose a question to the learned gentleman of medicine. About how many different types of medicine have been discovered or brought to light during the last 25 years? You can go back 50 years, if you prefer.

Dr. Selye: Well, if you let me go back 50 years, I would say that the vast majority of all medications which are really useful have been discovered during the last 50 years.

Senator MacDonald: Has it ever been discovered that any of those supposed medications, discovered during the last 50 years, were, to use the vulgar expression, worth a damn?

Dr. Selye: Very much so. I think, for example, that there has never been any medical discovery comparable in practical value to the discovery of antibiotics. If I could mention a single discovery which, to me, is the most important medical discovery ever made, it is the discovery of penicillin by Fleming. The discovery of other antibiotics followed but penicillin was the first of these. It and all other antibiotics, antisera and vaccines and the various hormone preparations are among the classics of very useful discoveries.

Senator Cameron: The questions, I have to ask may already have been asked while I was not there, and if that is the case you do not need to answer them. You indicated earlier in your discussion that you did not favour centralization in research facilities to too great an extent, and your reason was that if they were centralized and if a man applied for a grant and was turned down, that was the end of it, whereas if the research facilities were dispersed and if he was turned down in one area he might get support in another. Now this may be true, but the point of the question I want to raise is—in view of the fact that we do not have enough money to do everything we want to do, and we are not likely to have it, is it not desirable to have some measure of centralization of research funds and facilities in order that this body may establish the priorities and say in the national interests this or that is what we are going to concentrate on?

Dr. Selye: Centralization is desirable, but I think the *degree* of centralization and the way in which it is done is the decisive point. As has been discussed here by several senators, I think we will have very great difficulties in getting the plan through for various psychological reasons, such as regional patriotism, and even hospital patriotism and institutional patriotism. The art is in overcoming these things. If they can be overcome, and I should think they can with great tact, knowledge and understanding, without too much regimentation and by basing our arguments more on personal contact with people who have shown themselves to be capable of directing research groups, then it would be very valuable.

Senator Cameron: My second question is this: What is the rough estimate of the amount of funds being spent on medical research in Canada today? Have you this information?

Dr. Selye: I think the Medical Research Council now disburses \$27½ million.

Senator Phillips: I think that is correct...

The Chairman: This is only one source, though.

Senator Cameron: Apropos of what I read in the papers about some of the new directions which Canada is taking such as perhaps withdrawal even from NATO which might result in a saving of \$149 million a year to Canadians in which case it might be possible to divert some of these savings to medical research and to other forms of research—and I am thinking in terms of alternative efforts —if such an event were to come about, what do you think would be a reasonable national budget for medical research in terms of the needs as you see them today?

Dr. Selye: As I said in my first introductory statement, I would have to disqualify myself as not being competent to answer certain questions. I know what I would need. I now get about \$600,000. If I had \$1,000,000 I could work optimally and could make good use of it. But I couldn't use any more. There is a limit, and that is the amount I could put to use. I have been offered more space in our University and elsewhere, but I do not want an institute any larger than I can handle efficiently. If one were only the administrative director and engaged solely in supervision, then of course there would be no limit. You can run the whole Mayo Clinic and, even there, somebody must be the boss. But if you want to work in the lab yourself, there is a very definite limit which is related to your own intellectual capacity. In this context I could not use more than \$1,000,000, but I could use that million. It would help a lot if I could get even the \$600,000, which I hope to get, but without having to work so hard just to get it. As it is, I think I shall spend about 25 per cent of my time trying to obtain it. But getting the money without having to work so hard at it, would be the greatest boon to my research.

Senator Cameron: My own experience is mainly in the field of agricultural research, and in that field I know that substantial amounts of money come in from various sections of the agricultural industry, machine companies, chemical companies and even brewing companies and so on. Now at the present time the drug industry is in the process of a very substantial lobby in Canada at the present time. Have you any idea what contributions the drug industry is making to medical research in Canada?

Dr. Selye: Again I cannot make any authoritative statements about other institutions. I can say this much, however, that their contribution to our institute is virtually zero. We may get drugs free and if we have a congress they may pay the expenses of a foreign professor coming to Montreal, but even at this the contribution is negligible. The American and the Western Germany drug industry help us much more.

Senator Grosart: Should the pharmaceutical industry be contributing more in your specific area of research?

Dr. Selye: I think so. Taking for example Switzerland where there is a very highly developed national pharmaceutical industry, their contribution to national research is considerable but definitely not to their disadvantage. It is not given out of charity. In Switzerland the pharmaceutical industry is one of the major contributors to medical research and the program works very well for mutual benefit. If more foreign pharmaceutical companies would not just be content to stick the labels on their products in Canada but would actually develop their drugs here and work on their improvements, the process of developing better pharmacological research in Canada would be bolstered.

Senator Grosart: Would you consider yourself then in a position to support the basic purposes of the bill now before Parliament?

Dr. Selye: I have pretty well disqualified myself for politics to start with. These are political issues. All I can say is that the pharmaceutical industry could help us more.

Senator Grosart: That is the answer I was expecting.

Dr. Selye: Could I interject an answer to a question here while I have a chance to do so? I think when we are looking for excellence, it is true that it may be difficult to get many outstanding people to come. However, there is one point worth taking a look at here. I am referring to professors who are either emeritus or close to it. There are many countries where the retirement age is very low; one fallacy about this setup should be noted and called to the attention of the committee. As I said, the average life span at the beginning of the century was 40, and it is now 70. The retirement age, however, has not gone up in proportion. It stands to reason that a great number of people who are now 70 have the mentality which they would have had at 40 at the beginning of the century. There is no provision made for that.

In order to attract really outstanding people, if funds do not permit us to do it otherwise, or else to complement other efforts, we could start by getting people from other countries who have remarkable talents and who have established themselves in science but are retired. We would thus establish a suitable prolongation of the retirement age. In this way, we could get very outstanding people, even whole schools, who would be good for another 10 or 15 years.

The Chairman: A kind of Senate for researchers!

Dr. Selye: Exactly.

Senator Thompson: You were an international scientist before coming to Canada and, of course, it is very attractive to Canada to get international scientists to come here. In view of the wealth available for research you have in the States, what would attract you to come to Canada?

Dr. Selye: I arrived in Canada via the States. I originally came from Europe, but I did my post-graduate studies at Johns Hopkins University in Baltimore. I did come here by choice. I came not because I had to leave my country of origin or the U.S.A., but because I preferred to live here. Being of central European extraction, it seemed to me that I would feel more at home in a bicultural country. I received much of my medical education in Latin surroundings in Paris and Rome, and later in the United States and England. I actually came here for social reasons, one might say. I do not think that at the time McGill was a better university than Johns Hopkins which I gave up to come here.

Senator MacDonald (Queens): I know the hour is getting late, but I just want to pose one last question. We have several new universities springing up across Canada—and I am dealing now with Canada—and most have medical schools. How are we situated as far as medical professors are concerned to man the medical schools? Are they able to keep up with the requirements?

Dr. Selye: I think so, in general, but I believe that many improvements can still be made. We have nothing to be ashamed of, but there always is room for improvement—let us put it this way.

The Chairman: Time is marching on, and you want to go back to Montreal and to your research.

On behalf of the committee, I certainly want to thank you very much for coming and visiting us this afternoon. We have certainly profited greatly from your remarks and your experience. My only wish now is that in the future, after we have prepared our report, you will have more time to devote to research, that you will need less time to seek money and that you will be in a better position than you are now to plan your research activities.

Dr. Selye: Thank you very much Mr. Chairman, and I want to thank you all once more for having given me the honour of testifying before this committee.

The committee adjourned.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Thursday, April 18, 1968

The Special Committee on Science Policy met this day at 10 a.m.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: Honourable senators, if I were to introduce Dr. James R. Killian, Jr., to the members of the committee and describe his fantastic career in detail, he would have very little time to speak to us—which is, after all, the purpose of his presence with us today.

Fortunately, Dr. Killian's biography has already been circulated to the members of the committee and to the representatives of the press; and it will also of course be published as an appendix to our proceedings.

However, as a Harvard graduate, I would like to mention that Dr. Killian has devoted most of his life up to now to the expansion and improvement of one of the best institutions of higher learning in the world, the Massachusetts Institute of Technology. He became its president in 1949 and he is now chairman of the corporation responsible for its administration.

Dr. Killian has also been a most distinguished public servant. In 1957 he became the first Special Assistant for Science and Technology to the President of the United States and in this capacity he also chaired the President's Science Advisory Committee.

Because of his long experience, the strategic assignments he carried out over the years, and his well-known dedication, Dr. Killian certainly qualifies as one of the few wise men of science and science policy in the world today.

On behalf of all members of the committee, I wish to express to you, Dr. Killian, our deepest gratitude for having accepted our invitation and for being with us today. Dr. Killian.

Dr. James R. Killian, Jr., Chairman of the Corporation, the Massachusetts Institute of Technology: Thank you, Mr. Chairman. Honourable senators, I feel greatly privileged and honoured to meet with you here today.

For a long time I have been interested in science and public policy as a result of service in my government. Being back now in the academic environment, I have joined in teaching graduate seminars dealing with science in government; so I have a scholastic interest in the subject as well as a practical interest.

It has been suggested to me that I might report to you on some of the organizational and other arrangements in my country for dealing with advice to policymakers in government.

In doing this, I would hasten to emphasize that I am not suggesting that the arrangements we may have arrived at are necessarily relevant to your particular problem in Canada, or that they are necessarily any kind of model. I believe such plans must grow out of the local conditions in any particular country and that those in one country may not be applicable to another country. Therefore, I hope you will understand that I am not presenting what we are doing or have done in the United States, as something that you should feel was wholly appropriate, as you seek to find new ways of dealing with scientific activities.

I would also hasten to emphasize my great admiration and respect for Canadian science and what it has accomplished.

I have had the good fortune to know a number of distinguished Canadian scientists and my institution has the good fortune to have benefitted from some of your distinguished scholars, not only in the field of science but in the field of economics and other areas. Before coming here yesterday I cherked up and I was interested to note that at my institution today we have some 30 members of our faculty and staff who are Canadians and we have some 170 students from Canada at the present time. So I live among a Canadian community in a very real sense.

I would also like to note that I had the pleasure and distinction earlier this year of presenting the Atoms for Peace Award to Dr. Bennett Lewis for his very great accomplishments in the peaceful use of atomic energy.

I have been chairman of the trustees for one of the non-profit organizations in the United States called the Mitre Corporation, which serves the United States Defense Department. Dr. Solandt is a trustee of that institution, which is a rather unusual arrangement, but he is very welcome and is a valued trustee of that organization.

Let me turn to some comments about the topic you are dealing with here. In governments throughout the world today, science, invited or uninvited, sits at the conference tables where domestic and foreign policies are shaped. It can hardly be otherwise, since the revolutionary thrust of science and technology is constantly creating new conditions with which governments must deal. Yet, much of the subject matter of modern science and technology is arcane to the generalist-policy maker, and he has to call upon expert advisers who can make the complexities of science and technology meaningful in terms of their usefulness and relevancy to matters of state. Consequently, governments have had to devise methods of drawing upon their scientific communities for advice and analysis, and thus scientists and engineers have been drawn into the public arena.

This emergence of scientists in advisory positions at high policy levels has been most apparent since World War II. This has come about in part because of the role of science in defence and the rapid increase in public funds appropriated for research, and in part because of the high scientific and technical content of many of the major policy decisions our top government officials must make. The nuclear weapon, of course, has generated a flood of complex policy questions, as for example, in the field of arms control. The rapid growth of federally supported medical research and the push into space are creating still other sets of policy problems. The national space program particularly is interwoven with advanced technology and scientific objectives, and with such intricate problems as the proper organization for communication satellite systems, which I understand you are going to be discussing this afternoon. More recently, the urgent need to anticipate and prevent harmful technological fallout and to improve our environment, particularly our urban environment, have called for a high order of scientific and engineering advice. We are just beginning, I might add, to try to find out how science and engineering can contribute most effectively to the urban problem. I will come back to this subject later.

Policy questions such as these prompted President Eisenhower in 1957 to create a new position in his White House staff, that of Special Assistant for Science and Technology, and to appoint a member of the scientific community to hold that position. At the same time, he reconstituted an older committee that had been called the President's Science Advisory Committee, but which had really not served the president directly. Thus, he moved it from the Office of Defense Mobilization—where it had been established by President Truman to be largely a stand-by resource, informed and available in the event of emergency—and reorganized it so that it would advise him directly and personally on matters of science as they affected policy. He broadened its scope to include any and all scientific matters it felt should be brought to the attention of the president and his special assistant.

These moves, in effect, gave the United States' scientific community direct access to the president, or perhaps I should put it the other way: the president had access to the entire scientific community in the United States in a new way. This had not been true previously, except during World War II, when Vannevar Bush, as Director of the Office of Scientific Research and Development, served also as science adviser to President Roosevelt.

The mandate of the new Special Assistant for Science and Technology reflected then and, in somewhat different ways, still does today an extraordinarily broad concept of the relationship of science to policy making. The mandate that I received from President Eisenhower noted that I was to have, and I quote, "full access to all plans, programs, and activities involving science and technology in the government". I was to be available as an adviser to cabinet members and other officers of government holding policy responsibilities. I was to try to anticipate future trends and developments, particularly as they affect national security, and suggest future action in regard thereto: and I was to advise on "scientific and technological matters at top-level policy deliberations.

I might explain here that I was instructed that I should sit in on meetings of the National Security Council, not as a member of the council but as a person to be present, and on cabinet meetings where matters in which there was a scientific component would be discussed. I think this was of particular importance because it proved to be repeatedly true that problems would be under discussion at cabinet meetings or at National Security Council meetings where laymen might not have recognized that there was an important scientific component that should be recognized and dealt with as the particular matter was discussed.

This proved true where the presence of someone who had access to scientific developments and so on could call attention to the importance of looking at the scientific aspects of a given problem.

In practice, the special assistant has served as chairman of the President's Science Advisory Committee, though at the choice of the committee itself, since it was felt that this body should be able to act independently of the political commitments attending a member of the President's staff. I think there is a very important point to emphasize here in that anyone who is a part of an administrative set-up must, of course, participate and support administrative positions. But in complex matters of scientific policy it ought to be recognized that there should be another input that is free of this kind of commitment, if you will, to the party line of the administration. So it was provided that the members of the President's Science Advisory Committee, serving as consultants to the president, should have the opportunity to select their own chairman if they so chose, and they should have the opportunity of going directly to the president and not necessarily through the special assistant to the President. The President would therefore have available a group who were in no way necessarily committed to an adminstrative position in regard to a particular problem.

The representatives on the President's Science Advisory Committee covered a wide range of disciplines in the field of science. There were 18 or 19 members of this committee. They were drawn largely from the civilian scientific community—not from government agencies, although the committee has always asked representatives of scientific agencies in government to sit with them, not necessarily to vote with them but to sit with them when dealing with particular government problems.

The committee organized itself into a group of panels or task forces right from the beginning. Over the history of this committee one has seen about 10 or a dozen of these panels operating concurrently, and their frames of reference have ranged from matters of defence technology to science education to the general progress of our civilian, non-governmental science and technology. Many of their studies are undertaken because the special assistant is able to identify areas in the policy-making process where science and technology may have an important bearing not recognized by his lay administrative colleagues. Much of "PSAC" work is handled in ways that do not result in published reports, but a number of its studies have been issued as public documents by the White House. The first document that the President's Science Advisory Committee issued was on March 26, 1958, and was called "Introduction to Outer Space". This is an effort to formulate for the United States a space policy and to do it in terms that would be meaningful to the American people. This document had been prepared by a group headed by Dr. Purcell of Harvard, a distinguished Nobel Prize physicist. The document was presented to the Cabinet and the National Security Council and to other branches of the government. The President asked that it be widely distributed and in fact expressed the hope that it would be given the broadest circulation possible throughout the country. It was printed in a number of major newspapers and magazines and we estimated that at that time this statement coming from this group of scientists and engineers had a circulation running into six or eight million copies. It did have a public impact that was significant and led to tremendous interest in the United States space policy at that time.

Let me make a few more observations about the way the space program was dealt with. This followed upon the success of the

Sputnik and the reaction to it in the United States. The first assignment received from President Eisenhower was to make a report to the government dealing with space programs. We thought at first if we were to make a recommendation on how the United States government should organize to deal with space work we should first try to understand what the content of the program should be and build an agency that will be designed to do that kind of job rather than create an agency and then try to find out what the agency was going to do. As a result of this study by the panel of the President's Science Advisory Committee, conferring with people inside and outside government, it became the conclusion of this group that our space program should have a heavy civilian orientation. In the whole domain of communications and the use of satellites to study scientific problems in the space environment—all of these were of such importance that we should formulate an agency that had a civilian orientation. After making that study and issuing this report we came next to the problem of organization. And this is how the problems facing this panel were subsequently studied by the Bureau of the Budget and by the President's committee on government organization that was at that time chaired by Mr. Nelson Rockefeller. The Secretary of the Bureau of the Budget, Mr. Rockefeller, and I recommended that we reconstitute our old National Advisory Committee on Aeronautics which was operating laboratories and conducting research generally in the field of aero dynamics and had a diminishing mission because of the change in the technology in this field. We recommended that this agency be reconstituted into a new agency reporting directly to the President. It would be called the National Aeronautics and Space Administration, now known as NASA. Now this was one kind of report that came out in the early days of the President's Science Advisory Committee.

A second report that came out in 1958 was one dealing with scientific and technical information—the whole problem of how to deal with the enormous flow of literature in this field and how to deal with the problem of storing and retrieving such an enormous amount of material. That was the first of several studies in the field of what government policy should be with respect to technical information. We then published as a further report one called "Strengthening American Science". This was rather a comprehensive effort to try and define some of the larger goals we should be undertaking to make sure our science and engineering were first rate insofar as the federal government could influence this. This report dealt specifically with some problems of government organization, and one of the recommendations made was that the President should create by executive order a new agency in our government that would seek to bring together the key figures from all the major departments that had to do with scientific policy or administration. This was called the Federal Council for Science and Technology. As a result of this study and the presentation of this report to the Cabinet, the Cabinet approved the creation of this new agency in 1958. This is the place where all government departments come together to discuss interlocking and common problems and it is working out reasonably well although it has not always done what we had hoped for it in the beginning. The special assistant to the President serves as chairman of this particular group. As I said, these reports have had impacts on our government and have led to specific action.

We next published a report on "The Argus Experiment" in March 1959. This was a spectacular result of the efforts of the Science Advisory Committee to find out what would happen as a result of a nuclear explosion in outer space.

Then came a report on High Energy Accelerators for Physics Research (Piore Report), the first of a series prepared jointly by the President's Science Advisory Committee and members of the Atomic Energy Agency. These reports have led to government action and government policy with respect to the building of high energy machines in the United States which has been one of the really difficult and tough problems because of the high cost of these machines. The reports were of value to Congress in reaching decisions about the instrumentation of basic research of a very fundamental kind where large amounts of money would be required.

We next published a report on science education in the United States in which the committee sought to point out ways in which we could do a better job in the teaching of sciences in our pre-college schools. That was one of the reports that gave impetus to a major effort in the United States to upgrade the teaching of science in our pre-college schools, the kind of program that centered in Cambridge under the chairmanship of Professor Jerrold Zacharias.

Then in 1960 the President's Committee published a report on food additives.

Then came another report which related to graduate education in the United States. This was a very eloquent statement. I had nothing to do with it so I can fairly make this comment. The report stressed the importance of graduate study in the fields of science and engineering, on ways in which it should be strengthened, on the enormous necessity in our country of sustaining great centres of excellence, and on some of the ways we ought to go about building up strength in our graduate institutions.

A manpower study led to conclusions about the need to increase the production of Ph.D.s in the fields of science and engineering, and the necessity of a Government fellowship program to achieve this increase. This report had a very significant impact upon the Government action in support of fellowships and research grants of various kinds, for enlarging the capacity of our universities to train people to the Ph.D. level.

There was another report on Some New Technologies and Their Promise for the Life Sciences that began to open up the whole domain of bio-engineering, which is now becoming a major area of technology and science where the use of science and engineering as they impinge on medical science are of increasing value and importance.

There is another report which dealt with pesticides. This was generated, in part, by the appearance of R. Carson's now famous book alleging harmful effects of pesticides. That book really should have been anticipated by the scientific community, if I may say so. At least, there should have been an earlier study of the impact of pesticides that had a true scientific content. Here is an example of the growing importance of scientists anticipating technological "fallout", if you will, that may be harmful. There has not been enough successful effort to anticipate man-made environmental problems and plans to avoid them.

Another significant one was on the effective use of the sea. We have seen a growing group of studies, both on the part of our Congress and of the administrative group in government, on how one may deal more effectively with using the resources of the sea, not only to get more edible proteins, but what is now coming to be called ocean engineering, which is attracting more and more people and more and more industry, I am sure.

There was an other study of the world food problem, and so on. I cite these as examples of what a science advisory group can tackle.

At this point let me emphasize one of the special characteristics of the present Science Advisory Committee has been its apolitical quality; there have been no real political biases involved with regard to the committee. I think that no one of the three Presidents who have used the committee has ever sought to apply any political test to the appointment of people serving on the committee. I remember one President remarking to some of us that one of his political friends had said, "Don't you realize that the recent appointments are all men from the other party?" This particular President remarked that it was not a matter of concern to him, that he wanted objective advice and not political advice from this committee.

The next evolutionary step which took place was to respond to Congressional concern about having available to it adequate scientific advice. It quickly became clear that Congress felt the Administration, the executive branch of our government, had organized itself to get effective scientific advice, but that Congress had no access to this advice because it was privileged material which came under the canopy of the President, and Congress felt it did not know specifically what was going on in this domain. Neither did it have available to it the resources of this somewhat elaborate mechanism that had been created. A variety of points of view were expressed in our Congress about this. One was the repeated suggestion that we should have a Department of Science, and that there should be a cabinet officer heading that Department of Science. Another suggestion called for a special office devoted to science. The end result was that, as a result of these Congressional views that it needed scientific advisory resources for Congressional purposes, it was agreed that there should be created an Office of Science and Technology in the Executive Office of the President, which would be really built upon the Science Advisory Committee, but would be a statutory agency.

This office was created. The President's science advisor was made head and ended up wearing three hats: the chairman of the Science Committee; the President's personal advisor on scientific matters; and the head of the Office of Science and Technology. As the head of the Office of Science and Technology he was available to Congress and Congressional committees. As Special Assistant to the President he is not available to Congressional committees, so he has to find a way to divide his activities between these two roles. This kind of complexity and ambiguity, I am sure, you encounter in some aspects of your governmental processes here. Congress now has available to it testimony and reports from committees and studies, and so on, that it can use.

Now let me comment on the concept of a Department of Science, which has long been under discussion in the United States, a feeling we would have higher efficiency in our Government if we put all our scientific activities under one tent and had a single officer of the Government concerned with them.

This has not happened. It has been resisted in general, by the scientific community in the United States. It has also been resisted by the different agencies of our Government. It has been resisted by agencies of Government because they feel very deeply that scientific research and development should be limited to the missions it serves—for instance, that the Department of Defence must have its own research establishment serving defence needs, and that these cannot be served in some independent, separate agency of Government. Similarly with the Department of Commerce, the Department of the Interior, the Atomic Energy Commission, and NASA, all took the view you could not separate research from the specialized activites of these agencies. This has been the feeling of the Government, largely supported by the scientific community—not by all, by any means, but by influential members of our scientific and engineering community. They looked with apprehension on the monolithic, consolidated, centralized management of the enormous research activities of the Federal Government, and felt that such a concentration might, in the end, prove to be harmful rather than beneficial; and that we should avoid too much tidiness, if you will, and centralization, in the management of the great array of activities in which the Federal Government is involved in the field of science and engineering.

It must be pointed out that there have been other trends that have tended to help provide administrative co-ordination. The President's Science Advisory Committee serves in this role; the Federal Council I spoke of is the co-ordinating committee for all federal agencies, and there are other ways in which one gets co-ordination, but there has been no consolidation into a single department. I rather gather that this is under discussion in this country—that is, as to whether there should be a science department. I am not sure whether these considerations are relevant to your problem at all, but this is the history of what has happened so far in the United States.

Repeatedly the question comes up in our Congress as to whether there should be a cabinet officer concerned with science and research, or a department of science and research. Most of our Government departments have advisory panels or boards of their own, and qualified scientists and engineers as either full-time advisers or assistant secretaries to the cabinet officer. It has been repeatedly proposed on the part of the scientific community that each of our major departments have an assistant secretary devoted to research and development.

This has happened, in effect, in most of our departments, although those who occupy that position are not always called assistant secretaries. Examples include the Director of Defence Research and Engineering in the Department of Defense and the Assistant Secretary of Commerce for Science and Technology.

Incidentally, this position of Director of Defense Research and Engineering was created at the time of the Defence Reorganization Act of 1958. It was proposed by the President's Science Advisory Committee as a way by which the Defense Department could do a better job at the level of the Secretary's office. I think it is fair to say that this office has worked extremely well in helping the Department of Defense to deal with a lot of the natural service differences and rivalries that take place inevitably with respect to R. & D.

So much for some of the organizational arrangements and their impacts on our government. Let me now make some observations about the use of scientific advice at high levels of government, particularly at the cabinet level. These notes are written from my own experience as a special assistant to the President.

In his study of the Lindemann-Tizard conflict in England Sir Charles Snow rendered a very useful service by pointing out the hazards of the head of state's getting his scientific advice principally from one individual, especially advice on matters which are not open for public review and debate. Both the policymaker and his scientist-adviser, I would suggest, have a responsibility to minimize the danger of biased or highly personalized advice on esoteric or secret matters, especially in areas of science and technology, which could be fateful to the security of a nation. To ensure the best possible relationship between the policymaker and the expert, particularly in confidential matters of state, I would stress that both must be alert to the consideration that the policymaker should not feel that he can get all the scientific advice he needs from a particularly close relationship with a single individual, nor should any single individual feel that he is qualified to give the whole range of policy advice that would be needed at the top level.

A very interesting book was published several years ago in my country by Robert Gilpin entitled *American Scientists and Nuclear Weapons Policy* in which he discussed this question in some detail. He gave a valuable description of the difficult middle ground occupied by the science adviser between "the realm of science, on what is, and the realm of policy, on what is to be done", and how important it is that both the policy maker and the expert recognize that there is a different role to be played here although it would not be possible in many kinds of problems to separate completely these two roles.

There are many problems involving science in which one cannot easily separate science from political considerations. The whole domain of arms control is one example of this. There was the long controversy and debate we had in our country about nuclear tests cessation, and how one dealt with the problem of detecting nuclear tests in respect of which there were differences in the scientific community, and where it was very important for the policy maker to know that there were differing scientific views on this matter.

The policy maker often requires evaluations of projects or programs on which there has been a history of technical controversy, or of differing interpretations of technical facts by informed laymen. Two examples of this are the SST, the supersonic transport, and certain great water supply systems. These are two examples of projects in respect to which there has been great controversy.

In arranging for evaluations of controversies of this kind it is important to recruit the most competent scientists and engineers available and let them study the problem in an atmosphere as free as possible from past commitments and from personal or departmental positions. It must be recognized that there are certain kinds of technical questions to which scientists and engineers with complete integrity and with equal objectivity and competence will respond differently. The policy maker must recognize this. There must be checks and balances to ensure the best scientific advice can be provided for, in part, by proper organization.

As I have said, the President's Science Advisory Committee in my country has direct access to the President—at the pleasure of the President, of course. If it disagrees with his Special Assistant for Science and Technology, it can take an independent position and make it known to the President. As a board of consultants to the Special Assistant, it can also give him the benefit of varied points of view, and if he is wise he can use it to test his judgment and ensure against his own prejudices becoming dominant.

This mechanism has worked well now under three presidents, and has provided a range of views, an objectivity, and an uninhibited freedom of comment that no single science adviser could hope to match.

Let me add here quickly too that it is important in any government that science advice should flow from many origins in the government, through its own governmental departmental agencies and laboratories as well as from outside institutions. I would hasten to add also that I think one of the important aspects of formulating scientific policy is for a government to be able to have an organizational arrangement that makes it possible for there to be a steady flow of people from the civilian scientific community into government, and ultimately out again, so that the government bureaucracy is constantly refreshed by people coming in from outside with new ideas and innovative proposals.

I think that one of the most interesting things that has happened in the period since the war has been the arrangement whereby the President's Science Advisory Committee and its panels and all the advisory mechanism in all of the departments of government, have recruited people from the universities and from industry. These people have come in and spent time—part-time generally—in advising the Government. This has helped to refresh the bureaucracy, and the bureaucracy would agree that this has been exceedingly important. So, I think that this kind of an arrangement can be greatly helped by a freedom to use these kinds of people.

Mr. Chairman, there is much more that I can say here, but I think it would be better if I stop and become responsive to questions. However, I would like to touch upon very quickly something else that may be of general interest to you, and at which some of us have been looking recently. We have in our country at the present time a widespread recognition that the impact of research establishments, whether they be in universities or are Government establishments, can be very great upon the economy of regions and communities. This recognition, particularly in our Congress, has been the result of a great deal of discussion and, if you will, policy making with respect to how one allocates federal funds geographically in our country. This has raised acute problems of how one deals with the problem of geography in distribution—the problem of democratic distribution, if you will. I am sure that this debate will go on for a long time, but let me be more specific.

We have seen in the postwar period in different centers of the United States an extraordinary economic growth that has come out of university research activities. We have seen this in California, in the area around Princeton University, and around Chicago, and one can identify various other places where very large, active, and strong creative centers near our universities have produced an environment, if you will, as well as the people who have contributed importantly to the generation of new industry and new economic activity in their own particular communities.

We have had this kind of an effect somewhat spectacularly demonstrated in the Massachusetts and Boston community, where universities, notably MIT, have had a tremendous effect upon the development of new industry in that area, and where during World War II the research establishment developed at that time to deal with the problems of radar and communications led to an own-going strength and preoccupation with the field of electronics which has given Massachusetts a whole new industry it would not have had had not the universities been involved in this particular process.

We can now see on "Route 128"—which is the way it is normally dramatized—this tremendous array of new companies, most of whom have come into existence since the war; more than 400 of them, most of which came directly out of the universities through people who were on the staffs of the universities working on advanced technological scientific activities, or by the alumni who went out and started companies. There has been an outburst of the entrepreneural spirit coming out of graduate schools of these student institutions which has been surprising, because we have heard so much about students today not being venturesome, not willing to take risks, but we have seen an entrepreneural spirit on the part of Ph.D. types, people who got hold of an idea, saw it had commercial possibilities and sought to exploit it.

We have had a steady stream of people getting doctor's degrees and going out and establishing their own new businesses, firms based on scientific developments. These are science based companies. The fact that this is taking place in a really spectactular and very convincing way has led people all over the country to have a new view of what scientific research can mean, and therefore a competitive sense of the importance of having research establishments located in their communities. This is having an impact on the distribution of federal funds in recognition of the fact that communities all over the country feel they will benefit from having a substantial research establishment.

You doubtless may have observed at a distance the great struggle and debate that went on concerning the location of our latest new high energy machine, which is going to be an enormously costly development, which finally wound up, after a great deal of investigation and study, to be located in the Middle West, where there has been a feeling that there had not been adequate federal support of research activities. It is a good thing that it is located there, but it is an example, I think, of a new way in which the public and the political process has come to appreciate the importance of basic research in the sciences and how this recognition is affecting science policy.

Coming back to the impact of the universities and of federally supported research in these universities, in the Boston area, for example, a recent study was made by the Federal Reserve Bank in Philadelphia as to why this happened in, say, Boston, Palo Alto and Los Angeles, and is happening in some other cities of the country. I think they came to two conclusions. One was that there was a financial community in those places where it happened, readily accessible to scientist-entrepreneurs and in communication with the scientific and engineering community so that they had come to understand the financial industrial opportunities that could be found in new technical developments. There was a willingness to provide venture capital to help these companies get under way.

This has been a very significant part of the whole process, plus the fact that you had this group of scientists and engineers who were willing to go out and take risks and establish companies highly technical in content, and to join forces with these venturesome people from the financial community to get these companies under way. I am sure that in countries all over the world where there are scientific activities of significance this kind of effect will be of increasing importance as one recognizes that one does generate new industry in the universities and in pure research establishments and that we must find ways of harnessing this. I am sure this is an important matter for consideration in any study of scientific policy.

The Chairman: Before you end, would you care to comment, in general terms, on the perennial problem of priorities?

Dr. Killian: This is an extremely difficult problem of how one does two things, how one determines how much money should be spent in research development, and particularly how much money should be spent on basic research. I have never been able to find a clear-cut answer beyond saying that in basic research one should seek to support the creative people who are available to make contributions in this field, and by giving them adequate support we can get advances and the development of scientific strength that one needs.

There have been economic studies which show in effect that perhaps one ought to try to relate the amount we spend on research and development to the growth in gross national product that research and development is obviously creating, and somewhere between that growth and the amount you are spending one finds a figure which would be related in some objective way to the economic impact, although I do not think the economic measure, as for example in the field of health and so on, is necessarily a good measure for the amount of basic research. There is not any clear-cut answer that I know of to how one determines how much to spend by government in this field.

Coming to the problem of priorities, this is an extremely difficult question. One suggestion made some years back by Dr. Conant was that in dealing with the question of great machines or weapon systems, or other technological projects which require large sums of government money, perhaps one could arrive at decisions about the validity of these projects and their priority if one set up something of an adversary kind of procedure, wherein one established a panel, a technical count if you will, before which both the opponents and proponents would appear, and there would be the opportunity to challange and question both sides. He proposed that reasonable judicial people, even though they were not necessarily experts in under review the program under review, could arrive at a sound conclusion about the validity of these projects and their priority by this adversary procedure. Except in some of the panels that have been described I do not think this kind of thing has ever been really tried. One arrives at the priority in our situation by some helter skelter procedure where debate within the executive, debate within the scientific community, debate within Congress in the end comes up with some sense of what is important.

One constantly hears the argument about priorities within the field of science and technology itself. You have the question of whether nuclear physics should have a higher priority than biology and so on, and it is awfully difficult to resolve. Should space have the priority it now has? Are we devoting too much attention, effort and money to space? I am not suggesting what the answer is; I am only saying that there is a wide difference of opinion on the question of priorities here.

It has been suggested that in the federal government's handling of these difficult questions of priority, in the field of basic research, it should be assumed that it is almost impossible for the administrator to deal successfully with questions of priority in pure science or basic research. This is for the simple reason that only those people deeply involved in the problem of basic research, and generating their own concepts of what is important, and where they should go, can really make meaningful judgments. One has to take their capacity to chart their course on faith as being a sound one. Given publication and given all the things that go into scientific research processes at the basic level, this is probably a sound point of view to take; but when one gets into domains in which the other fields of science become competitive, or where the public interest becomes competitive, particularly in terms of the scale of expenditure involved, the interest of the taxpayer, if you will, then one should involve in the process of decision making and selection a member of the public who looks at this, not in technical terms but more broadly in social and economic terms.

I am myself convinced that it is important, when one considers the building of a great nuclear centre or nuclear reactor, or a great high energy machine, or one of the many enormous instruments now found necessary in dealing with scientific research—an astronomical observatory or a great telescope, which may involve the expenditure of millions of dollars—the decision whether to go ahead with this ought to be arrived at as a result not only of very sound technical judgment being brought to bear, but that there should be representatives from competing fields of science. In that case, the biologist may say "We have a problem which is more important than that of astrophysics, in our judgment, and you want to look at this, too." Those groups making the decisions ought to involve representatives of other fields of science, and also ought to involve representatives of the public, so that one can get the other points of view, in making decisions that involve large scale expenditures.

I am afraid I have not thrown much light on your question.

The Chairman: Thank you very much, Dr. Killian. Now, proceeding to the question period for about fifteen minutes, Senator Cameron will initiate the discussion.

Senator Cameron: Mr. Chairman, I need hardly tell you how fortunate we are to have a man of the breadth of experience of Dr. Killian before us today; and I would like to congratulate you and the committee on getting him.

There is one question which he answered and on which I will start, as I should like to underline it, to make sure that there is no misunderstanding. We in Canada of course have not the resources in money or personnel that your people have, Dr. Killian, in the United States. Therefore, one of our problems, in evolving a national scientific policy, would be how to mobilize our resources most effectively. There are suggestions being made that we should, as has happened in the United States, set up a ministry of science in the government.

If I understood you correctly, I think you stated that the decision in the United States was to stay away from this. I want to get a very precise answer to this, because in our stage in development, my own feeling is that we should not have such a person, that it should be done under one of our agencies and not as part of the cabinet. On this, I would like to have your opinion.

Dr. Killian: My judgment about what would be right for Canada would not be good or necessarily relevant. However, I can be very explicit on what seems to be the preponderant opinion in my own country. This has been definitely opposed to consolidation that would be represented in what we would call a department. This has been opposed by the operating agencies, who feel that they must have control of their own research, relating it to their own missions.

Secondly, the scientific community in general—not all, by any means—have taken the view that they do not want a monolithic controlling mechanism which they feel might be so centralizing that it would tend to dominate all the science in the country, and they fear this very greatly, in our particular political system.

For that reason, there has been very little that the proponents of a department have been able to mobilize among the scientists. There have been some very ardent proponents of some degree of additional centralization. One of these groups has long advocated a greater degree of centralization and organization in what is called the environmental sciences. By that they mean geophysics, weather, oceanography, and so forth. We have come to bring together a grouping of the environmental sciences in our country at the present time as a result of this. But this has not gone beyond that particular grouping.

I am sure, however, there is going to be a continuing debate in our country as to whether we should not have a department of science. It is conceivable that there might be some middle ground reached, where we might bring together the National Science Foundation, NASA, the space agency, and the Atomic Energy Commission, all of these being special agencies created for special purposes in the government. I think that such a grouping may be a long way off if it should ever occur.

Senator Cameron: But you are satisfied that a sort of umbrella organization can be provided under which these various agencies you have enumerated could have their thinking co-ordinated to some extent?

Dr. Killian: Yes, I think it is possible to create a co-ordinating mechanism that will be helpful, although that will not provide against all possible duplication or all possible competition, for that matter, in different fields.

I would have to say that one of the interesting reasons why people in the civilian scientific community would look with disfavour on a central source of funds in government for scientific research would be that they find strength in the diversity of sources at the present time; and while it may be untidy, while it may result in some duplication—although not much—it does free us of the possibility of having one particular group controlling most of the funds going into science in the country.

Senator Cameron: My second question relates to this one. You say that all of the government departments have their own scientific advisory committees?

Dr. Killian: Yes.

Senator Cameron: And that they function with some measure of independence, and this is desirable up to a point. What systems of checks and balances have you provided to avoid duplication of the work?

Dr. Killian: In the main, this occurs through our Bureau of the Budget. The Bureau of the Budget must approve all departmental budgets, the whole government operation. That bureau has come to be very sophisticated in dealing with problems of research development in science. This has come about in recent years. There was a period when they had not dealt with this strange kind of government activity in any large scale way, and it took a long time to begin to get some of the standards and guidelines as to how one handles such.

I would hasten to say that the Bureau of the Budget turns to the President of the Science Advisory Committee and its panels very frequently for advice in regard to science programs.

The Chairman: Would the Bureau be in a position to avoid duplication or to assign priorities?

Dr. Killian: It would try to avoid duplication and it would try to get a sense of priority, through the budgeting process.

Senator Cameron: In a sense, the Bureau of the Budget does establish priorities, in saying which field can receive money for its program?

Dr. Killian: There is a sense of priorities involved in this budgeting process.

Senator Cameron: My third question I direct to you in your capacity as an educator in science, as well as a person who shapes public policy. Again we come back to the fact that our country, compared with yours, is relatively poor in terms of resources, budgets and manpower.

We have had a proliferation of new universities in Canada in the last few years, particularly in the last seven or eight. There are some 25 new universities. The question of staffing these universities is exceedingly difficult, but it is more difficult still when you get into the area of research.

Every university, for prestige purposes, wants to say that it has got a first class school of, for example, petrochemical work, and so on, even if it can only have one man of distinction in the particular department.

It seems to me, and here is where we can draw on your rich experience, that we have no option but to concentrate our research facilities in specific institutions. For example, if we are going to train the graduate students we need, they cannot get the challenge to their minds that is desirable if they go to a relatively small institution which may only have one or two top flight minds in a department. A student must have exposure to a dozen or more of these men. That is why so many of our people go to Stanford or Harvard, or places like that, where they can get depths of resources.

This seems to suggest that Canadian universities, at this time particularly, have to agree among themselves that they will allocate the areas of specialization and deliberately build up depth in departments. For example, Toronto is already well known in aeronautical engineering.

Dr. Killian: Yes, it is.

Senator Cameron: My own university is known in petrochemical work, because that is a natural there. But there is a constant fight among these beginning universities in that they feel they have to duplicate these others.

How do we evolve a policy to meet situations of that kind?

Dr. Killian: We have the same problem in the United States. There is a growing number of institutions all seeking to augment their prestige and their strength. Commenting on the United States scene I have been very explicit in stating my own views that I think it is essential for the welfare of all our institutions that there be a few centres of superlative excellence. It is our hope that we can multiply the number of these centres as we go along, but this should not be done by taking away from the centres of excellence that already exist in order to help create a greater number of institutions.

We should try to phase this so that we can create the new centres of excellence slowly; we should keep and strengthen the ones that we already have as we work on the development of new ones.

We run a very big risk in the United States today that, because of the rapidly growing number of institutions and because of our political pressures, which are very natural and to be expected, to spread the wealth, so to speak, or to spread our funds and support across the country, in a manner that will result in neglect of the centres of excellence we already have.

I think we need debate and constant discussion about this problem, in order to arrive at a solution of it. I am sure that it is a difficult problem to handle, but I come back to my conviction that we must have these places which, through historical or other reasons, have come to be world centres of importance and significance and creativity and that you should do everything possible to sustain those institutions and help them be still more significant, because they feed strength to all of the others. Particularly in the field of science, anything less than top flight is not good, and you need this kind of superlative quality to raise the level of the system as a whole.

As you look at some of our own major universities—some of them state institutions such as the University of California and some of them private institutions such as Harvard—you find that they are providing people and providing new research and scholarly results and, therefore, tend to, as I say, sustain the whole system. They are therefore enormously important.

Senator Cameron: I am grateful to you for the emphasis you have placed on the way universities generate new industry in the entrepreneural sense, because this is not the usual characteristic attributed to universities.

Dr. Killian: And it is only a side affair, really. It is not the principal objective.

Senator Cameron: I do not want to monopolize too much of your time, but I have two more questions which I would like to put to you. In the paper which you read at Johns Hopkins University on April 26, 1964, you stated that 80 percent of the federal funds as of that date were going into research and development. I am sorry, that should be that 80 percent of the funds for research and development were being spent by the Defence Agency and the Aeronautics and Space Administration. The total amount at that date was $18 billion of which 1.5 billion was for basic research. Now, that was in 1964, and I wonder if you can tell me the relative figures today?

Dr. Killian: Well, I would think the total federal research and development expenditures today—I am rather puzzled by that figure of $18 billion.

Senator Leonard: That includes the private sector?

Dr. Killian: The present federal expenditure for research and development falls close to $17 billion.

Senator Cameron: It was 15 then.

Dr. Killian: Yes, it has increased. I would judge the total amount going into universities at the present time for both educational and scientific research expenditures is of the order of $3 billion out of 17. I would like to get those figures more precise if I can, but I know that the total federal expenditure is about 16.8 or $16.9 billion in 1968. I may have some confirmatory figures on that somewhere. While I am looking for it you can go ahead and ask your other question. I should say that one of the positions that has been strongly taken by a number of people representing science and engineering in the United States is that we should seek to increase our basic research at the rate of 15 percent per year. This reflects the natural growth in research opportunities and the manpower available and so on, but also they feel there is a need for this kind of regular annual increase to take care of inflation and rising costs. We have been going through a period where we have had an annual increase in research and development expenditures which are now levelling off and we are going to have some real problems in dealing with inflation and so on as a result of the levelling off because of tightness in the federal budget. They don't know what is going to happen between now and the end of the year. Interestingly enough the National Science Foundation had had an increase in its budget for 1968 and that is devoted to basic research, but it is modest in relation to the total expenditures.

Senator Cameron: What percentage is going into private industry?

Dr. Killian: A very substantial portion of federal R & D funds go to private industry. As you can see from the figure I quoted for the universities, a great majority goes to private industry. This is a significant fact because the federal government has been a principal source of research funds in industry, particularly in those industries that relate to defence and space in the United States. There has been great support for the aerospace industry, for example, which is included in this total.

Senator Cameron: There is something that relates to this; some of us have been wondering about what happens in the event that peace breaks out while this high percentage of your resources is being spent in these two fields, defence and aerospace research? Have you set up the machinery—and I am sure you have—so that if peace breaks out, say, next year or the year after to transfer this to civilian or peacetime work?

Dr. Killian: I am not sure we have any mechanism which deals directly with this problem, but I would make this observation—I would be very hopeful that if research and development expenditures can be cut back for the purposes of defence that we can devote this money to the support of health programs, urban programs,—the whole domain I was speaking of that affects the health, welfare and the environment where there is a desperate need for more research activity than we have at the present time. We are already finding a shift in emphasis from defence into some of these fields and there have been enormous developments in recent years in our national institutions on health, and their activities in research programs are a spectucular example. It is an interesting fact that the Department of Housing and Urban Development has appointed a research director and is undertaking a research program in the field of urban and housing research and all things relating to that. Also we have more efforts to do research in the field of transportation.

Let me cite an example of that; a year or more ago the Department of Commerce concerning itself with the responsibilities now vested in our new Department of Transportation came to my own institution and asked if we would undertake a hurry-up study of what technology would be available with respect to high speed transportation systems between Boston and Washington. We were able to monopolize a group of people, mechanical engineers, civil engineers, people from management—an inter-disciplinary team all of whom were interested in this program. They did a crash study on a transportation system for the northeast corridor looking at this from the point of view of what technology could make practical in the years ahead. They came out with a report that clearly indicated that the development of very high speed rail transportation was technologically feasible. I am speaking now of higher speeds than the Japanese are using at the present time. This report was presented to the Department of Commerce and as a result the President sent a message to Congress recommending a very substantial appropriation for the all out study of high speed rail transportation problems. These studies and the series of investigations on the part of industry and universities are currently under way.

This in an example of funds moving in other directions having to do with a civilian economy. I would add that there has been a lot of discussion in the United States as to whether our emphasis on defence research has not diverted talent and funds away from those things that would contribute to the civilian economy. But I believe that even that would not be contributing towards the development of more consumer products.

Senator Cameron: I go into Seattle and Los Angeles and to Wichita, Kansas, and I am frightened by the attitude of some people who seem to have tremendous vested interests in the *status quo*. They are afraid of what will happen to their jobs if peace should break out and it would appear to me that we should now start publicizing the alternatives.

Dr. Killian: A number of different organizations in the United States today are diversifying their programs. I think that industrial companies that have been primarily aerospace companies in the beginning are now starting to look at a whole range of other activities. I think of one major company in our own New England area that now is looking to the field of educational technology. Then, you also have a number of the big companies in the United States—for example General Electric has teamed up with Time-Life to develop an educational subsidiary devoted to new educational materials and technology. Raytheon is now engaged in the manufacturing of educational materials, laboratory equipment, publishing, and so on. They are diversifying in many other ways.

Some of our not-for-profit corporations, which I have not touched upon—I spoke of Mitre that Dr. Solandt and I are involved in—they are all looking towards the possibility of making a contribution of their particular skill developed for defence purposes, to other domains. It is quite possible that corporations like Raytheon and Mitre and the Institute for Defence Analysis, and so on, will be making their particular qualifications available. Rand, which was started originally to do operations analyses for the Air Force, has spread to doing many studies now for the Department of Defence, not only in terms of the substance of the studies, but also in terms of the people they train. It had a profound effect on Mr. McNamara's administration of Defence. Rand has entered into a contract with the City of New York to undertake a study of some of its urban problems, applying systems engineering concepts to its urban problems.

One sees the Institute for Defence Analyses —on a modest basis, because its primary commitment is to the Department of Defence —making very interesting and new kinds of studies for the Crime Commission, applying technological concepts to the whole problem of dealing with law and order. Some of the other not-for-profits are beginning to look at urban problems.

I am convinced that if we are going to deal adequately with university resources, as applied to urban problems—and we must find a way to do that—we are going to have to create new institutions which can work between the universities and the field of action involved in the urban process to make this possible. Some of the not-for-profits are going to be useful in this regard.

We had concern at the end of the war about what was going to happen when peace broke out and, fortunately, there was a tremendous economic surge ahead. I do not know that I am qualified to comment on whether that can happen again, but I think we must find ways of rapidly adjusting, and some have already been found.

The Chairman: I had the impression you already have expressed the view that whatever happens in the Vietnam war, for instance, the research effort for defence purposes should go on.

Dr. Killian: Very definitely, and there are continuing problems that will need continuing effort. So, I do not think we are going to see the Defence R. and D. disappear, by any means; there is going to be a major effort continued in that field. The whole field of anti-ballistic missiles is one example.

The Chairman: Again, this morning I turn to my left!

Senator Leonard: You are going further and further to the left!

Senator McCutcheon: I have one very general question, Mr. Chairman. I would like Dr. Killian, if he would, to give us his opinion as to what he thinks the proper proportion of R and D government money should be in each of the three fields where it is spent: in Government laboratories; in private industry; in the universities. Are the universities receiving too small a proportion, or is too much work being done in Government laboratories that might better be done in private industry?

Dr. Killian: I do not know how to answer that particularly in your context, sir. I do not think there has been a deliberate judgment about this in my own country, as to what the distribution should be among these three sectors. All of them are seeking additional funds, most of the time. However, I think clearly that in our own situation the majority of the federal funds are appropriately flowing into industry at the present time, because it is related to many Government undertakings and missions that industry is carrying out, particularly in the fields of Defence and Space. But, certainly, there has been an increase in funds flowing into the universities. That may be levelled off or even cut back in the immediate period ahead. In fact, all our R and D may be modified in the face of budget stringencies. I do not think anyone quite knows what is going to happen here, but there has been, in general, a trend in the United States towards support of R and D external to the Government. We have some first-rate Government laboratories. The NASA program, with several major exceptions, is handled in-house, in NASA's own laboratories; the Space Center in Houston, the NACA, its precursor, had its own laboratories and they are fine laboratories.

On the other hand, the Atomic Energy Commission has contracted out to industry and universities all its research activities. Hanford has an industrial sponsor; the Argonne operation is a University of Chicago contract; Brookhaven is operated by a consortium of nine universities; Oakridge is managed by a corporation. The Air Force has no laboratories in-house, to speak of. It has a few, but most of its operations for research and development are contracted out, either to industry or universities. We have a mixed system, but I think a preponderance of the work is being carried out under the management of non-government institutions.

Senator McCutcheon: Thank you very much.

Senator Grosart: Dr. Killian, is this allocation of federal funds, public funds, between these three levels, a matter on which the President's Advisory Committee would advise the President?

Dr. Killian: Yes, it is likely the President or the Bureau of the Budget would ask of his Office of Science and Technology for comment or study on this; but I do not recall that there has been a deliberate examination of the distribution of funds by these three categories, except a general discussion about the needs of the universities particularly. I think it has been felt that the Defence Research, for example, comes about as a result of the needs of the overall Defence budget, and one does not make that decision in relation to the funds that are going to the universities or what is being done within Government or without. It makes that decision in terms of Defence needs. I have seen no examination of the distribution of funds because of this Defence factor, Space factor, and so on.

Senator Grosart: I noticed some figures from the National Academy of Sciences, that from 1955 to 1964 the percentage of total Government Research funds going into Government laboratories was 78 per cent in 1956, and it dropped to 27 per cent. Was this not a matter of policy, or how did this happen?

Dr. Killian: I think it grew up like Topsy, not so much as a result of an overall Government policy, but rather as a result of a general, widely held view within the Government that the best way to get research done within our own context was by contract with outside agencies.

The Department of Defence still operates a number of its own laboratories, and these were research laboratories, for example. In general, there have been problems in the operation, in our country, of Government laboratories, in-house laboratories, because of the Civil Service requirements and restrictions on the payment of salaries, and so on. This has been greatly improved in recent years. The upgrading of Government salaries has made it possible for an increase in the salary scales of different people at different universities, and those people are now in a better position in relation to industry.

But, again, I would stress that we have a mixed picture. One would have to say that the policy of NASA of running its own laboratories has worked out extremly well, whereas the Atomic Energy policy of contracting out all of its work has also been successful. However, from the figures you will see that the majority of the work is contracted out.

Senator Grosart: Is the investment of 15 per cent in R and D public or private money—that is, the 15 per cent acceleration that you mentioned?

Dr. Killian: I would say that that ought to be a combination of public and private money, but the amount of public money is so dominant in this picture that you are really talking about Government appropriations for the support of research.

Senator Grosart: Would these figures of Government spending include any proportion of state spending?

Dr. Killian: There is not much state spending in the United States on research and development. Some of it is beginning to appear at the present time. I think the State of New York is beginning to do some very novel things in respect of the universities, both public and private, by establishing Professor Albert Einstein professorships with high stipends. There are certain research activities going on in the states.

I would like to see more of our states doing more research on their own, particularly research that would fit the economy of those states, and research that could have a very real impact upon their own future. Some of us have advocated that the states ought to have better scientific advisory mechanisms than they have had. In fact, the Governor of the State of Massachusetts has a Science Advisory Committee. This is true also of Pennsylvania and New York State, and, I am sure, many of the others.

Several years ago at our annual Governors' Conference some of us were invited to attend and talk about the handling of science policy in the states. There was an obvious tendency for the states to do more. However, it is still a fact that what they do is negligible when it is compared to the federal contribution.

Senator Grosart: I am sure, Dr. Killian, that one of the questions that are agitating Canadians who are interested in this field is that of how much we should spend on it. What would be the total expenditure in Canada on R and D. Do you see any validity in relating this to the GNP?

Dr. Killian: Yes, as I mentioned before—let me read you a statement made by Dr. Weisner, who was also Science Adviser to the President after Dr. Kistiakosky, made a couple of years ago on this matter of determining the expenditure levels for science and technology:

> Three per cent of the gross national product in the United States is currently spent on research and development. While in Washington, I tried to find some optimum rate of research and development investment for our country, but with little success. The only concept I have been able to apply is that of an upper limit. From the point of view of economic growth, increments in research and development should not exceed the increased productivity that they make possible... To use this measure properly, it is necessary to actually predict the total future value of a given research and development expenditure. This is obviously not possible, so I will assume that the upper limit for research and development expenditures in a given year should be the entire increased output due to productivity increases in the same year. This is obviously very conservative...

That is one effort to deal with this problem of a limit, but, again, I would have to say that I think that that is where the difficulty lies.

Senator Grosart: In other words, the suggestion there is that it might be based on the real increment in GNP.

Dr. Killian: That is right.

Senator Grosart: That is, excepting inflation, and so on.

Dr. Killian: Yes.

Senator Grosart: I have one final question. I was very interested in hearing that you, as the Special Assistant to the President for Science and Technology, sat in on cabinet meetings. I got the impression that this is perhaps the most operative part of the marriage of science advice and policy and decision making. It would seem that this is something that is not feasible in Canada in view of certain constitutional concepts that we have about the cabinet.

The Chairman: Were you participating in the discussion at the cabinet meetings?

Dr. Killian: I was invited to sit in at cabinet meetings.

Senator Grosart: Yes, you said that.

The Chairman: But, did you participate in the discussion?

Dr. Killian: Only when there was an opportunity to make some in-put that was relevant to what they were discussing.

Senator Benidickson: I believe that that has happened in Canada.

Dr. Killian: I know that Dr. Hornig attends cabinet meetings, just as the special assistant for security in our country attends cabinet meetings and NSC meetings. The economic advisers do also. These people are present when matters that are relevant to their own fields are being discussed. I think that this is very important.

As a matter of fact, during my regime and Dr. Kistiakorsky's we sat in on all NSC meetings, and on a number of occasions it was possible for us to point out that certain developments in science could be meaningful in terms of the matter that was under discussion, and we had a free opportunity to do that.

Senator Grosart: How would this operate? Would you be notified that a matter of scientific judgment was to be under discussion at a certain cabinet meeting?

Dr. Killian: Yes.

Senator Benidickson: Mr. Chairman, I think that you would confirm that this would not be unusual here. The important thing, I think, is that cabinet has much of its detailed preparatory work done in committees.

The Chairman: Yes, in cabinet committees.

Senator Benidickson: Yes, and at the cabinet committee meetings you have your scientific chairman. They use the same room, or perhaps another room, and a very large group of people are invited to contribute to the discussion and the eventual decision.

The Chairman: Yes.

Senator Grosart: The question I was asking you, Dr. Killian, was: In your experience do you see any techniques by which the President or the secretaries in charge of departments were able to get over the hurdle of the laymen attempting to assess conflicting scientific judgments?

Dr. Killian: Yes, I think I saw a number of examples of that. I will cite one example which occurred in my particular day. There was a discussion in regard to nuclear testing and the fallout problem, and so on, and because there had been an extended examination of this problem by the President's Scientific Advisory Committee I was able to report to the President and to the Secretary of State and others that I felt there was a scientific and technological basis for a re-examination of the whole nuclear test problem. This had a definite effect upon their planning and decision making with respect to this and out of these discussions, and against this background, there was created an inter-agency committee on nuclear tests detection that was headed by a member of the President's Science Advisory Committee, Dr. Hans Bethe of Cornell.

That committee made a study, as a result of my comment at that meeting, and reported back to the NSC in a full dress session on this question, and that report and subsequent activities led to subsequent actions that provided the background for a committee of experts to meet in Geneva with representatives of the Soviet Union and other countries. After that meeting came the long and arduous discussions and negotiations that led ultimately to the nuclear test ban treaty.

Senator Grosart: So, it is possible to develop a decision-making technique in this area?

Dr. Killian: Yes, I feel that it is very possible. I can think of another kind of example, of where a panel of the President's Science Advisory Committee had a look at the program then under way for the development of a nuclear propelled aircraft. This is in a rather controversial domain. This panel came up with the conclusion that we should limit our effort to R and D and not undertake any hardware.

This report was made to the President in the presence of some of the proponents of the programs and the President reached his decision against the background of that discussion at that time and did limit the programs then. This subsequently became public information. There were people in Congress who felt differently about this. The problem immediately arose as to whether this report of the panel could be made available to the Joint Congressional Committee. The President was very concerned, as all our presidents have been, to protect the privileged character of the information available to him and said it could not be. Actually this was subsequently handled by the Department of Defence. The cabinet officer, the Secretary of Defence, who had dealt with this problem in Congress, asked this committee to come together as a committee of the Department of Defence and render a report to him, so this put it in the public domain where it could be used in a discussion with Congress. These are some of the kinds of thing that represent this effort to deal with both the legislative and the executive branch in an advisory capacity.

Senator Aird: I should like to ask one general question. I think society at large is very concerned about the accelerating gap between technological advances and human wisdom. I know about your own efforts in this field, and I know with your background you support the quality input into the humanity education field. My question, sir, is: are you satisfied about the progress that is being made in this area in your country? Perhaps some comment might be in order on the relative importance that is being attached to mankind's ability to handle the gap with these scientific technological advances.

Dr. Killian: I have quickly to say that I am not satisfied with the progress we are making. I say that there is much to be done to learn how to deal with the impact of technology particularly. But I think there is a growing preoccupation with this problem, not only in my own country but all over, and here too, as you indicate. I have been interested to observe the shift in emphasis in my own institution in this respect, where now we see a constellation of faculty who are becoming preoccupied with problems that have to do with urban environment, with transportation, with bio-engineering, and with all the things that have to do with the quality of our life along with the quality of our technology.

I also hasten to say that I do not think we are going to deal with this problem by cutting back on the sciences, by cutting back on technology. We cannot deal with this by imposing a regime of ignorance on ourselves, so to speak. I think it important that we become more mindful of predicting in advance better than we have been in the past the effects of the technology that we are generating and therefore enabling ourselves to take forward measures in making sure that the effects are benign rather than creating problems for ourselves.

I think we must have more and more accommodation in the behavioural sciences, the social sciences, the humanities if you will, in dealing with these problems and bringing to bear scholarly judgment that would be useful to the policy-makers. In my judgment the real way to deal with this is to make the inter-disciplinary approach more effective than it has been in the past. I am speaking of the educational environment particularly. We currently have people from all over our institution, from the School of Management, from the humanities, from social sciences, from engineering, from architecture, from city planning, all participating in an institution-wide program devoted to urban affairs. This is an example of this new kind of mobilization of all the disciplines to deal with social problems of the kind you are asking about.

The Chairman: Is the federal government giving increasing encouragement to research in the field of the human and social sciences?

Dr. Killian: Slowly. Several years ago we created two agencies of the federal government, somewhat analogous to the National Science Foundation, to deal with the arts and the humanities, although I must say they have been very inadequately funded so far. We now see efforts being developed to create research programs in life sciences and related activities on a large scale. We see now efforts to create, still on a modest scale, research programs in fields like housing, environment, transportation, all the problems that represent urgently needed understanding in our country.

Senator Desruisseaux: I think my questions have been answered already, but I would be curious to have an appraisal on this. I refer to the GNP contribution to research and science in the world now, for instance in Sweden, France, the United Kingdom and the United States, where there is a very large gap in relation to the percentage of this amount being used for research and development. As far as I know it is unknown and I would very much like to have some views on whether this gap, shown in a country like, for instance, Sweden, to be some six or seven per cent of the GNP—I cannot remember the figure exactly—has produced justifiable results in these countries for the amount of increased expenditure in relation to the GNP?

Dr. Killian: I think one must answer that in the context of one's sense of values about those particular societies. It is certainly true that some countries are spending substantially more of their gross national product on R and D than, say, you are, or we are, and they still apparently have acute economic problems.

It is a very complex question and I think the whole domain of how one handles R and D and applies it and manages it is a very good part of this. I think the whole argument about the technological gap may in the end be an argument that should be directed at education and management as much as it is directed at science and engineering. I think the whole question of how we get quick action out of the research we do, how we communicate these new ideas in a way in which they can be applied, how we develop a relationship between the university doing basic research and industry and government so that they benefit from this basic research, depends to a great extent on this inter-flow about which I was speaking earlier, of people moving from university into government or industry and back again so that there is cross fertilization and communication going on.

Finally, it also depends on how one manages, particularly in industry, effectively to put science to work and to increase productivity as a result of good management and of good use of technology.

I am deeply convinced that one of the major parts of this picture is the relationship between the scholars in the universities who are working at the cutting edge of their fields and the workaday world, and how the work of a scholar is translated into useful activity outside of the university.

I think one can say that in those countries where there is a close articulation between the university community of the country and say the industrial community, one finds very definite impacts of economic importance in that relationship; and when there is not, when the universities are remote from the industrial community, I think one finds less results flowing out of the scientific and technological research.

One's sense of values may provide a different interpretation of this and of the role of the university, for that matter; but I do think it is quite clear.

Sometime ago a group of us were involved in a study, under the auspices of NATO, of the feasibility of creating in the European area an international institute of science and technology that would be specifically oriented towards providing central research facilities, that would be closely articulated with the industrial economic life of the European area. This kind of institution, for some special reasons, has not come about; but I think we were all convinced—and the late Sir John Cockcroft was a member of this group, and we had a German representative, an Italian representative, a French representative and so on—we were all deeply convinced that the pilot operation this might provide in the way of seeing how research and development in the university could be related to the economic life of those countries, offered a very great opportunity.

Senator Grosart: May I ask a supplementary question? Do you know of any useful yardsticks of this cost-benefit relationship? In R and D expenditures, are there any yardsticks?

Dr. Killian: As I said earlier, I think this is a very difficult problem and one has more or less to play it by ear. I know of no objective ways of determining how much one should spend on basic research in a given situation—beyond, as I said, trying to make sure that you provide for the creative people of the country to be adequately supported to do their creative work. I think this is the best test one can apply, as to what money should be devoted to basic research.

The Chairman: It becomes easier to apply these tests, I suppose, when we reach the stage of development work?

Dr. Killian: It does; but it looks as though, given the experience of countries as a whole, there is a tendency for this R and D expenditure, to be in the order of 2 per cent to 3 per cent of the GNP. That is the general standard at the present time, and that has come about as a result of many different judgments and many different circumstances. It may be about as objective a basis as you can arrive at.

Senator Desruisseaux: I have another question, if I am not taking up too much time. As to the findings in the field of science, are these being carried out in the way of exchange with other countries to a large extent—the findings that you make. Is there some way by which these findings are communicated to other countries?

Dr. Killian: Certainly in the university world these findings are all in the public domain and are all made available. In the industrial field, naturally, they have a proprietory interest in their research and development, which the companies tend to protect, and this is understandable. The only other domain where there is classified research is in the atomic field and defence field, and that naturally is under wraps of a certain kind. Personally, I feel there is still too much secrecy, even in the defence field, but some is absolutely essential. In the field of basic research and in university work in general there is complete freedom for publication and availability.

The Chairman: Would it be true, to say that the United States relies less on the results of research done abroad, than other countries do? We were told, for instance, that the Russians relied very much on research made in the United States?

Dr. Killian: I think we rely very greatly on work that is done abroad. There is so much in the total commonwealth of science that depends upon intercommunication between groups, and one should not ever be caught up in the parochial view that any one country has got all the resources to do its own work. Certainly, the United States has enormously benefited from scientific activities in other countries in the past, and still does; but we are more on our own now than we used to be. I hope we are contributing in effective ways to other countries, but we are still very dependent upon research in other places.

Senator Thompson: In this interchange of research, with a view to giving the greatest scientific power, is there an approach to development, and a lack of duplication in other countries? In other words, do you talk to them about their national purpose in science? I am thinking as well of external aid. Is the scientific research conscious, too, of your external aid?

Dr. Killian: I am sure that there is duplication, but I am not troubled by the duplication, I think you need multiple approaches in attempting to solve many kinds of problems in conducting many kinds of research. I may also hasten to say that in the field of open research, where results are published, the scientific community very well knows what is going on, and they police themselves with respect to duplication. This is not necessarily true when you get into proprietory fields, when there is an effort to keep the information confidential or secret. I see no way of preventing duplication there.

Senator Thompson: On the second point, of your emphasis on research development in a community or a region, is there an emphasis placed on external aid, of encouraging the scientific community in a region? I am thinking perhaps of the populated areas of the world where you might say in the United States "We will try to develop scientists to go into those areas, rather than economic aid alone."

Dr. Killian: I feel there is a very definite opportunity to do that. For example, one sees effort in the local communities to amplify their research capacities particularly for economic purposes. In North Carolina we have seen the development of a research triangle, that relates Duke University, Chapel Hill, and the State University at Raleigh, and the group of research activities there, that I am sure it is stimulating the economy of that region.

Some of the industrial companies have gone in there and built plants or research laboratories.

We have seen the industrialists in Dallas, Texas, come together to provide funds to create a graduate research centre in Dallas, the purpose being purely one to increase research activity in that area, to increase the size of the technical community and make it possible for people to have opportunities for advanced study, and so on. Industry in that community felt the need to do something of this sort and sought to create the resource to do it. This is the sort of thing which has been going on with regional or local effects.

As I say, there are great incentives now all around the country to turn to R and D activities and to strengthen education in order to help the economic circumstances.

Senator Thompson: Would some representative from the scientific community perhaps examine the requests of an emerging nation which is asking aid from you, to suggest that, "perhaps these are things you might want for prestige value as an emerging nation, but we would suggest that it might be wise to work in some other development"? Is there a relationship between your science community and your external affairs people?

Dr. Killian: Right. I think so. Incidentally, in the whole field of contributing to the development of underdeveloped countries, I think a great deal of study and research has gone into that on the part of the university groups particularly. And we have a centre for international studies at my own institution, and one of the major focuses of that is the study of the application of technology to the needs of underdeveloped countries.

But, as I say, domestically and internally, there has been a great and growing recognition of the importance of finding ways of putting science and technology to work for local development.

Senator Leonard: Mr. Chairman, I have just one question to put to Dr. Killian in connection with the organizational structure at the top echelon of formulating science policy. As I understand it, there are really four parts to it. There is the personal adviser to the president; there is the advisory committee; there is the science council, coming from the departments of government; and then there is the Office of Science and Technology.

Dr. Killian: Yes.

Senator Leonard: And this relates to the Congress itself. What type of manpower, that is, in number and in size of budget, is involved in these four parts of the formulation of government science policy?

Dr. Killian: Actually it is very modest.

Senator Leonard: Very modest?

Dr. Killian: Yes. There has been an effort to keep the staffing of this bureaucracy modest. Frankly, I do not know the total number of people, but I suspect that all of the staff involved in this operation would be less than 40 or 50 at the present time. The office of Science and Technology and the staff supporting the President's Science Advisory Committee and the special assistant comprise a small group. It has been criticized as being perhaps inadequately staffed. But I think there has been the countervailing view that it is important that it not grow to be too big and cumbersome.

One of the big things to be recognized here is that so much of the impact of this activity comes because of volunteer participation, because all of these panels are made up of people who have been drawn from universities, from industry and sometimes from government agencies as well. They may get a per diem allowance, but actually the compensation provided for these people is not a significant measure of the service they perform.

Therefore, you are drawing upon the resources of the country and getting judgment, counsel and analysis there. So this keeps the bureaucracy down and makes it unnecessary to have a big staff. It makes it important to rely upon these people who come in from the outside.

Senator Leonard: Are the members of the President's Science Advisory Committee employed there full time?

Dr. Killian: No. They all have other full time occupation. They meet once a month and sometimes oftener, and meetings of the panels take place. So they do spend a lot of time doing the work.

Senator Leonard: The reason, then, that there are four components of this structure formulating government science policy is constitutional to a certain extent. Because the president has certain powers he has a personal adviser and because the cabinet has certain powers there is a science advisory committee. And there are the departments themselves and there is Congress. Presumably those four groups or four sets would have different points of view on some one particular matter. With Canada's constitutional structure, however, which differs from that of the United States, possibly there could be some telescoping of the functions of these four components that you have in the United States.

Dr. Killian: Yes, I think so. In the beginning there was only the one, the President's Science Advisory Committee, and it had a rather small staff.

Senator Leonard: Thank you.

Dr. Killian: One point I have not touched on at all in my remarks is the problem of the Congress getting scientific advice other than through the executive branch of the government, and this is something that has troubled Congress quite a bit. One of the ways in which this is being met at the present time is for Congress to turn to the National Academy of Sciences or the National Academy of Engineering. As a matter of fact, one of the congressional committees has entered into contract with the National Research Council, related to the cabinet's needs with respect to scientific advice. In the last seven or eight years it has undertaken a series of major studies on the part of panels or committees that it has mobilized to make reports available to Congress. So that congressional committees of this kind have the benefit of this kind of advice.

However, I still do not think it has adequately solved the problem of how Congress can get the kind of analyses and studies that it really needs in order to deal with some of these complex problems. Some of our congressional committees have built up substantial staffs, though. The Joint Committee on Atomic Energy has a very competent and strong staff in support of its activities. These are very knowledgeable people. Some of the other congressional committees have also been conducting open hearings like you have here with respect to science policy, and the Science and Astronauters Committee in the house has had a whole series of foreign visitors come to appear before it to talk about these difficult matters. But they are seeking on the legislative level to do what you are doing to get a total look at the problem.

Senator Hays: Dr. Killian, at the outset you mentioned that you had dealt with several scientific problems. One that you mentioned concerned insecticides. How did you specifically deal with that problem? I suppose it was the problem of residue in so far as insecticides are concerned? How would you deal with that specific problem?

Dr. Killian: The Science Adviser to the President, with the advice of his science advisory committee, set up this task force to make a study and prepare what was expected to be a public report on this problem. They tried to find the best personnel in the country to serve on that committee, the most knowledgeable people from the scientific community and agriculture particularly, and they did come together to make a very careful and comprehensive study. They produced a report which was then issued by the White House as a public document under the imprint of the White House.

It certainly had impact on all the government agencies that have regulatory and other responsibilities with respect to the problems of insecticides and it helped to shape public opinion, and I think this is the way you have to go about it.

The panel was not able itself to make any decision about what government departments should do, or anything of that sort. It simply tried to mobilize judgment as background for action by executive departments or by Congress. This has been the general way.

The National Academy has made a number of studies of this kind, and there are other kinds of studies that I might mention here that have been going on. Currently, Congress has provided for two concurrent studies of the whole field of marine resources. There is a subcabinet committee which is under the chairmanship of the vice president.

They then created another group which was to be made up partly of representatives of Congress and partly of members of the scientific and engineering community. That is headed by Dr. Julius Stratton, the former President of MIT, now the Chairman of the Ford Foundation. That committee will report to Congress and we will report to the Committee of the Executive Branch, as I say. They are trying to formulate the basis for government policies in the whole field of oceanography and marine sciences.

Senator Hays: In your other paper you dealt a bit on the sea in so far as water use is concerned, and on the great fight between Arizona and California for the use of water and also on Israel's water problems. Are the documents concerning these matters published?

Dr. Killian: Most of them are published, yes.

Senator Hays: Regarding both insectifides and water problems?

Dr. Killian: Yes.

Senator Hays: What were your findings in so far as water is concerned and its uses from the sea?

Dr. Killian: I don't know, but I could get a copy of the report. These are all public documents published by the Government Printing Office.

Senator Cameron: While we are on that point, could you get a copy of the report to the President on Transportation problems and the study which you referred to earlier?

Dr. Killian: Yes.

Senator Lang: My question really rises from Senator Leonard's and brings it from the particular into the more general area. Has the increasing orientation in the United States towards science and the rise of your science secretariat as referred to by Senator Leonard created any strains in your traditional system of congressional checks and balances or has it created any constitutional shifts in power as between the federal government and the state governments?

Dr. Killian: I am sure the whole impact of science and technology on our government processes has created shifts in a number of different ways. There has been a very good book written on this problem by Dean Don Price, Dean of the School of Public Administration at Harvard. In this book he deals with the impact of science on Constitutional methods and processes. One of the things he refers to is "federalism by contract"—the growing tendency of our government to turn over to public non-government or quasi-government agencies the task of making studies and recommendations or taking action on behalf of the federal government and he points out how this has greatly widened the activities of the executive branch of government and also dispersed these activities in new ways. All of these non-for-profit organizations are examples of this. Take the Department of Defence, for example, and the Institute of Defence Analysis to which it looks for operations analyses for the joint chiefs of staff. This is an independent corporation doing work for the federal Government. Then, there is the Rand Corporation which has conducted many different studies of defence problems. This is a private agency under contract to the federal government. Then, we have some universities operating big programs and big laboratories like the Lincoln Laboratory, the Livermore and Los Alamos Laboratories and others under contract to work for the federal Government. As Price said, this is a new element in our whole political and constitutional process in which the Government has delegated to a new instrumentalities a lot of the functions one would more normally assume that the government would do itself.

The Chairman: To add here my personal comment on the impact of technology on our federal structure, I want to point out that I recently summarized the evolution of federalism in Canada until 1940 by saying "Give me the railways and I will give you the federal government; give me the automobile and I will give you the provinces."

Dr. Killian: The impact of technology has increased to a great extent the work of government organizations. Thinking back to the end of the war we have had the creation of several different organizations. The Atomic Energy Commission was created, NASA was created and the new environmental sciences administration has been created and they all deal with technological problems. One can cite many more examples, and I would add that all the big national laboratories have come into being over this period.

Senator Lang: How do the senators and the members of the House of Representatives react to this new orientation?

Dr. Killian: There have been a whole complex of reactions in the legislative branch and I think Congress has had considerable concern about the way these non-for-profit corporations deal with the federal government, what their relationship is to the government and what their performance has been. This whole thing has been the subject of a great deal of debate in Congress. There has been a debate in Congress about the President's Science Advisory Committee and the fact that the executive branch of government has better and more opportunities of getting information than has the Congress itself. There has been congressional debate and concern about the effect that technology has had and its impact on the congressional process itself. We have had the creation of a joint committee on atomic energy. This is still a debatable kind of arrangement. One hears criticism of the arrangement but one also hears support for it. By the creation of this committee dealing with this esoteric, complex field it has come to have legislatively a monopolistic control of this program because it knows so much more about it than anybody else and because so much of it is classified. There have been proposals that we ought to have a joint committee to deal with space. But this has not come about yet. There have also been proposals that we ought to have a joint committee to deal with research and development. It has been recommended that there be a department of science. One of the reasons frequently presented for a department of science is that if there was such a department the Congress would have one place to took to for information and they could expect that the head of that department would be available to Congress to discuss its program whereas now Congress finds it has one committee dealing with the Department of Commerce, one with the Bureau of Science and one dealing with NSL and so on. This has been one of the difficult problems for Congress—to find a way of getting an overall view of the entire program. There are real problems still existing here that I am sure we are going to hear a lot of discussion about in the future. Again, the Congress at one time set up a select committee in the House to look at the research and development program and to get a comprehensive view of it. The Committee on Science and Space has begun to look comprehensively at the total research and development program and thereby have a central point of information and study and analysis of all of our scientific policy activities from the legislative point of view; but it is still quite independent of the Senate for example.

Senator Lang: Can you comment on the action of the states generally to the new atmosphere—the individual states?

Dr. Killian: Well, there are so many different points of view here it is hard to zero in on any of them. I come back to the point I made earlier that I would like to see our states take more of a role in research and development and in trying to pursue those objectives that would serve those states in the context of their special needs. I am hopeful we will see more of this. It may well be that in the future it will be possible to begin to offset perhaps the changes in the federal program on research and development by the states beginning to augment their role in this field. It is now almost wholly a federal role.

The Chairman: But there has been no objection on the part of the states to the federal government taking the major responsibility in this field?

Dr. Killian: There have been some reactions but no significant actions in countering this simply because the states have not had the means, the funds and the attitudes that would help them to become first rate. One of the things that has troubled people—and I am included among them—is that the states and, in fact, our cities have not been able to command the quality of scientific support the Federal Government has been able to command. This is a very real weakness in our federal system.

Of course, one must hasten to say that in this federal system the states and the Federal Government are getting to be very much intertwined and interwoven in a lot of their activities, and the states do participate in many technological programs—for example, the Land Grant College program, in Agricultural Research, and so on. Many of the states now administer federal funds, particularly in the field of education.

Senator Kinnear: I want to ask Dr. Killian, Mr. Chairman, about the great advance in technology and the gap it leaves with the unskilled people. Have you done any research on what is going to happen to the unskilled and the people who could not be educated to a higher level?

Dr. Killian: Yes, there has been a great deal of concern about these problems, about the fact that technology is tending to require greater levels of skills, more skills, and that the unskilled person is more and more in difficulties, in a technological society.

I think that now we have seen, particularly in response to the emergency situation we have had, that all our effort, in our country particularly, on the part of industry, with the support of Government, to undertake training programs, to up-grade the unskilled, to find ways in which they can be productively employed and which give them a sense of being part of our society and having a role to play in it that is significant. But it is not an easy problem, and the percentage of our skilled workers who are required to keep our society going is steadily increasing and, therefore, the demands for more education and more training are steadily increasing.

Senator McGrand: My questions have been mostly answered, but I want to follow up the question Senator Aird asked you, because I think it is important enough to be repeated.

When you answered Senator Cameron's question, you mentioned the problem of these prestige colleges and the newer universities, and the prestige consciousness over new universities, and concerning the development of techniques and research that are going to be forthcoming. I would like to know where all this expansion and research is going to lead to eventually. Technology and automation are replacing people.

On Tuesday evening I watched a TV program entitled, "Canada in the Twenty-First Century." There was a very large panel, and one panelist, I believe, was from Columbia University. He said he would not recommend another student going into chemical or physical research; and then he went on to explain he would advise them to go into psychology and sociology, in an effort to adjust society to the upheaval that research physical research has created, and to dispose of, in a way, this great backlog of technological research that has piled up. Would you please comment on that?

Dr. Killian: First of all, let me be quite clear. I am not one of those people who feel that by cutting back on science we are going to be able to find better ways to manage the contributions that science and technology make. I think we are in a period in which we are extremely creative, in your country, in mine, and in many other countries. We are in a phase of human development where science is enormously productive, and we want to get all the human benefit out of that productivity we can.

I do not believe you are ever going to gain, either socially or politically, by trying to deny this creative thrust that we see going on, all of us today. This is something very precious and valuable, and we ought to give it its head and encourage it in every way we can.

I would also add to that my feeling that more and more, by the proper relationship and articulation of science with the Social Sciences, and with other fields, that science is going to be able to contribute to the solution of some of these social problems, in very important and fundamental ways.

I would cite, for example, the development of the Behavioural Sciences, taking, as they do, scientific research of a very important kind and providing new understanding and new approaches to the management of human problems that are involved in our society.

In many other areas we find scientific methods—such as in psychology and other behavioural sciences—scientific approaches to the solution of urban problems, and so on, being able to make meaningful contributions to the quality and humaneness of our lives.

So, I do not think we are going to gain, and I would not agree with the position you quote on the part of this person, that we are going to gain by trying to deny or circumscribe the advances you can make in this way. I think we must be very mindful of the problems of anticipating and funnelling the effects of scientific research and development, and we must mobilize and strengthen the Social Sciences and Humanities in any way we can.

I would hasten to say that one of the things that have concerned me very much has been the defensive attitude in the Humanities generally, because somehow they feel they are in a backwater—many of them are not, but there has been a lack of relationship of the Humanities to the current problems of our time, and we need to see the Humanities more in action than they have been. We desperately need them and the qualities they can bring to bear, but we need to carry them on in concert. I am all for strengthening the Social Sciences in every way we can, recognizing that there is a relatively new area, in terms of scientific aspects of the Social Sciences, which they are still struggling to get on a solid, scientific base, but I cannot go along with the theory that one is going to gain by plowing under the sciences or engineering as a scientific activity.

Senator McGrand: This question is perhaps a continuation of at least my thought. You referred to Rachel Carson's "The Silent Spring".

Dr. Killian: Yes.

Senator McGrand: You indicated that scientists should have been aware, or should be aware of what is going on, and that her book did bring out something that had been overlooked.

Dr. Killian: Let me be very specific on that. I think that scientists were quite aware of some of the effects on the whole ecological problem involved. I think scientists could have done a better job of calling attention to the awareness they had and making known the fact we had problems here, and alerting all the different agencies and people involved, to these problems. This is what I mean when I say that scientific and technological communities, it seems to me, have a new responsibility in our time to anticipate these kinds of things and to point them out at the earliest possible opportunity.

Senator McGrand: There were people in the field of science who repudiated her book and who wrote articles to that effect.

Dr. Killian: There was controversy about some of her conclusions, and all that. I will not get into that; I think there was a basis of criticism of some of her conclusions. But, what I am talking about is the fact that she did in that book call attention to a range of problems that we certainly have to deal with, and there are many other aspects of technological fall-out, if I can use that term, in respect of pollution of many different kinds.

Senator McGrand: Sometime ago I read a book which pointed out that most of our medical problems and many of our diseases are man-made. It listed them and suggested that they were caused by air and soil pollution, detergents, insecticides, and a number of other chemicals. It also said that what we consider to be new diseases are really old ones. A few years ago one seldom heard of hepatitis, but much about it is heard now, and that this was caused by soil contamination, the use of antibiotics, and so on.

It seems to me that there should be a great deal of co-ordination between the advances in each field of science. They should be co-ordinated more than they have been in the past. Had there been such co-ordination this sort of thing would not have arisen.

Dr. Killian: I agree that there should have been more anticipation of these effects, and more co-ordination in order to deal systematically with them. I would hasten to point out that there are also tremendous advances arising out of medical research—and here I am referring to problems of health, and the health of communities—that have been marvellous, and which constitute one of the great accomplishments of our time. I would say also that some of the problems we face today come about because of population increase, and so on. It is a complex situation. But, I do agree with the point you are making, that we need to deal more comprehensively and on a systems basis with the impact of technological change.

The Chairman: I should like to ask a final question. Dr. Killian, you have placed a lot of emphasis on the importance of what you call the science administrator in the administration of an efficient science policy. My question is: What qualifications would you expect from this science administrator?

Dr. Killian: I would say that he ought to have a sound grounding in the field of science or engineering so that he has insights and understandings of it. He should also be able to adjust himself to the public arena, and be able to deal skillfully and understandably with the political processes. This is of very great importance.

I would also hasten to say that we need more scientists and engineers in our legislative bodies. We need more of them in government, taking on the normal kinds of administrative responsibilities and exercising the normal kinds of legislative responsibilities. We need the people who have the insights of science just as we need people who have the insights of law in order to make our technological society work.

I think the method of how we are to give our scientists and engineers the educational background that would lead them into these other things is an educational problem. I would also hasten to add that there are other kinds of scientists and engineers who are restricted to their fields, and whose contribution should be that of working in a laboratory environment, where they will be most productive. Such people will not fit into the public domain because they will not be happy or able to make a contribution there.

What we need are more of the kind of people who can translate the purely scholastic, retired, monastic kind of scientific research environment into the public environment, and our technological society is going to need more and more of these people in order for it to work.

Senator Thompson: Do you have any scientist who is a member of the Congress or any of the other elected bodies?

Dr. Killian: We have only two or three. I forget what the number is now, but there are not very many. But, they are beginning to show up in our State legislatures, and in various other ways, and, of course, there are many in the administrative branches of government. One finds many science-backgrounded people at sub-cabinet levels and in administrative posts in the American Government right now, and this is a good sign.

May I go back very quickly to a question that was asked previously about the amount of federal funds going into different fields, because I have found the figures?

Obligations for basic research have arisen from \$1.8 billion in 1966 to an estimated \$2.3 billion in 1968. These are federal funds. As a share of total federal research and development, basic research has risen from 12 per cent in 1966 to 13 per cent in 1967 and to 14 per cent in 1968. So, this is what the trend has been there.

Applied research obligations are expected to increase from \$3.4 billion, where they were in 1966, to \$4.1 billion in 1968. This component accounted for 22 per cent of the federal R and D total in 1966, and will account for 24 per cent in 1968.

Development obligations have grown from \$10 billion in the fiscal year 1966 to an estimated \$10.9 billion in 1967, but are expected to drop to \$10.3 billion in 1968.

I think that those are the most recent estimates of the National Science Foundation with respect to the distribution between these three categories of research and development.

Senator Leonard: Mr. Chairman, I am sure that we are very much indebted to Dr. Killian for the contribution he has made to our deliberations. It has been a great privilege for us to partake of his wisdom and experience. What he has told us will be invaluable to us, and the committee is grateful for his having come here.

Dr. Killian: I have learned a lot too.

The Chairman: We will adjourn until 3 o'clock, when we will hear the Honourable Mr. Drury, Dr. Solandt, Dr. Gaudry, Rector of the University of Montreal, and Dr. Weir, on the White Paper on Communications Satellites.

The committee adjourned.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Thursday, April 18, 1968

The Special Committee on Science Policy met this day at 3 p.m.

Senator Maurice Lamontagne (*Chairman*) in the Chair.

The Chairman: Honourable senators, this afternoon we are departing from our normal activities to discuss a specific subject of more immediate interest than long-term science policy, namely the problem of communication satellites, which has been analyzed recently in a White Paper published under the authority of Mr. Drury, who is still, at least for a few days, the Minister of Industry.

Mr. Drury will open the discussion with a brief statement on the main features of the report. He will be followed by Dr. Roger Gaudry, Vice Chairman of the Science Council and rector of the University of Montreal, who will present the report in the larger perspective of the views of the Science Council as to the overall space problem. Later on Dr. Solandt, and perhaps also Dr. Weir or Mr. Whitehead, will probably want to add to these initial statements, and then we will proceed to the usual question period.

On behalf of the committee I am very pleased to welcome Mr. Drury in particular, and all our distinguished guests. I should like to mention that the Chairman and Vice Chairman of the Science Council, Dr. Solandt and Dr. Gaudry, are accompanied by Dr. Gordon Patterson, Professor of Fluid Physics and Director of the Institute for Aerospace Studies at the University of Toronto. We also have at the table Dr. J. R. Whitehead, Principal Science Advisor in the Science Secretariat, who had a special responsibility in, I think, directing the Task Force whose work formed a basis for the White Paper.

Honourable C. M. Drury, Minister of Industry: Mr. Chairman and gentlemen, I am very grateful to the Chairman for providing me with what might be the last opportunity to appear. I know as well as you do how effective he is, and he has been working heart and soul to disestablish or abolish the department over which I preside! His few kind remarks may just be in the nature of a preliminary obituary.

I have not got a formal statement on the communication satellite, and you have only very recently had distributed to you a quite thick document, this handsomely bound paper entitled "A Domestic Satellite Communication System for Canada". I would assume that most of you will not have had an opportunity to read it. I will try to give some kind of an outline of the background leading up to this, and if there are any questions of a technical nature Dr. Whitehead will be more than competent to answer them.

Long distance communications in Canada are carried terrestrially on the earth either by lines, wires, hollow cables or a microwave system, which is a form of very short wave high frequency radio signal which requires no wires to connect it, but there must be a line of vision between each of the transmitting and receiving towers. It means, then, that for our communication system, as we have it in areas of high population density, there must be a lot of hardware on the ground to cover the very long distances we have.

Latterly the load imposed in respect of information transmission on this system has been growing very rapidly indeed and the microwave system on the ground has also been expanding very rapidly to meet this, but it is quite clear that the rate of growth is likely to accelerate rather than level off or slow down.

Recent technological advances have made possible a rather more economical method of long distance communications than perhaps the microwave system, and that is the synchronous satellite. The satellite operates on the basis that there is a transponder, using the technical term, which is a small receiving and transmitting station hung up in the sky about 23,000 miles from the earth. The signals are beamed from the earth to this satellite transponder and are re-transmitted back to the earth. If the satellite is positioned above the equator and within about the centre third of the North American continent, a signal transmitted from that satellite would cover the whole of Canada from the east coast of Newfoundland to the west coast of Vancouver Island, and north beyond Resolute Bay. Therefore virtually the whole of inhabited Canada can be covered by a single satellite broadcasting to Canadian territory. However, for the reception of these broadcast signals, very elaborate and quite expensive stations are needed. The reason for this of course is that the signal coming from this great distance, 23,000 miles, is very faint indeed and requires substantial amplification.

It will not be possible for some considerable time yet, anyhow, for individuals to own receivers which will be able to pick up the transmission from the satellite or make it available for their own use. This of course has particular relevance to transmission or re-broadcast of television programs, for which the microwave system currently makes extensive use and of which the satellite will make extensive use.

These will only be rebroadcast to special receiving stations and retransmitted from there to the normal television broadcasting systems.

I mentioned that the instrument, the satellite up in the sky, is a transponder, which means it receives and retransmits.

Depending on how it is built, it can broadcast on any of a number of frequencies, of a wide range of frequencies; but there is in the spectrum only a limited number of these available frequencies. As this broadcast will cover the whole of Canada—and incidentally part of the northern United States—we must have reserved to us frequencies which other people will not be using to interfere with our broadcasts or rebroadcasts.

There is available to Canada—and to other countries, incidentally—only a limited range of frequencies. In order for Canada to get for its exclusive use a series of frequencies which we want, it was felt we would have to stake our claim early to this set of frequencies, before other people appropriated them and put them into use for themselves.

To meet then the problem of an economical means of expanding our telecommunication system, and to meet the challenge of time, in order to establish a system of frequencies which we would have for use from the international telecommunications system, a task force was organized under the chairmanship of Dr. Chapman.

This group undertook a study of what was being done elsewhere in the world in this field, what was being done and what could be done in Canada. In this area, I may say, we had quite an exciting experience, and a very successful experience, too. The task force proposed to the Government that an endeavour should be made by Canada to take advantage of existing Canadian technology and to give it a further encouragement and boost in terms of development, to produce in Canada, or largely in Canada, telecommunication satellites which would supplement our existing terrestrial telecommunications system.

A proposal for doing this, and an outline of a way in which it might be done, is contained in this White Paper. Briefly, the White Paper recognizes that the new telecommunication system should not overnight make obsolete our existing investment in terrestrial communications but should supplement in an orderly way our existing communications.

The White Paper also stated that an endeavour should be made to harness the initiative and enterprise of Canadian entrepreneurs, at the same time retaining a sufficiency of government control of the operations to ensure that the public interest would be protected.

To do this, the task force has recommended that a corporation should be formed, which would be partly private and partly government, to design, build and launch the satellite and to operate the ground receiving stations.

I mention the ground stations because this is an essential element of the satellite communication system. Without the ground station, one has nothing. Probably the corporation which owns and operates a satellite should also own and operate the earth link to it, although there is a possibility of having ground stations constructed and owned by agencies and bodies other than the corporation. In such event, the satellite operation would be entirely at the mercy, under the control, of those who own the ground stations. To make the system complete, it is probable that the satellite corporation should own the ground stations.

To advise on the corporate structure of this new corporation, the services have been obtained of Dr. McIntosh of the Bank of Nova Scotia, who is currently conducting a study with those having an interest in this operation, with the view to making recommendations as to the corporate structure of this satellite corporation. Perhaps he might even propose a name for it.

I may say, parenthetically, a word as to where this fits in, in the world sphere of things. There are some communication satellites already in operation and given the style of a geostationary or synchronous satellite, which is one which is in orbit above the equator and rotating at exactly the same speed as the earth and consequently appears in terms of the earth to be stationary, which is the choice we have made.

The Russians have instead launched and are making use of a system of satellites in elliptical orbits which pass over the U.S.S.R. once in every circuit. To maintain continuous communications, obviously while one satellite has passed beyond the Russian purview there must be another one coming in to take its place, followed by another one. This requires quite a number of these continuously orbiting satellites passing over the home territory and it also requires rather more complicated receiving and transmitting apparatus, because these have to track and to keep continuously focused on the orbiting satellite.

The Russians have a system using orbiting satellites. An international body known as INTELSAT has a satellite over the Atlantic, a relatively small one, I think, with two channels, and one over the Pacific with two channels. Both of these are geo-stationary.

A European consortium, mostly Germany and France, have plans to set up, to launch and put into operation a communications satellite, also synchronous, which they have named "Symphonie". It is not getting ahead quite as quickly as they had hoped.

Apart from the Russian satellites, the INTELSAT corporation satellites are engaged in international traffic; and Canada is a shareholder in the INTELSAT corporation and subscribes to the notion that all international satellite communications should be provided through international instruments rather than through national instruments.

Our proposal in the White Paper does not run afoul of that in that this satellite is designed exclusively for domestic Canadian communications. It will handle only transmissions to and from locations in Canada. It is not in any way intended to be used for international communications.

We will continue to subscribe to and support the thesis that, for international satellite communications, resource should be had to international and internationally controlled corporations.

We will be, I hope, if this goes through, the first country to have a domestic communications satellite. This is perhaps a natural for Canada, giving perhaps two features. First, our considerable technological success, particularly with the Alouette, which has surprised and pleased Canadians with its performance, shows that we have the ability and the technological know-how to do this. Secondly, the vast expanse and relatively thin population of Canada makes satellite communications relatively much more economic than the conventional land line or microwave systems, which become more economical only when there is a high density of population. When there is relatively low density, as there would be in Canada, the satellite becomes much more attractive economically.

On the timing, we have had prepared a form of work flow chart, and it is planned to have the satellite in orbit in 1971, if it is a small one, which means up to four channels, or in 1972, if it is a larger one. I leave these options open, because at the moment it has not been clearly established what are the costs and other parameters of a four-channel satellite as distinct from a 12-channel satellite.

I may say the numbers four and 12 are chosen in that for any number of channels up to four—and a channel means a television channel—one launching system is practicable. But when you go from four up to 12 you require a bigger vehicle, a bigger "bird"; another system of launching has to come into play, and it is very much more expensive to us. This is why the option is four or 12, really. The cost and possible loads on a satellite have not yet been determined with sufficient precision to say which is the optimum or the best at this time.

I am not sure that I have added much to your understanding. Would you like to add anything, Dr. Whitehead? Or would you prefer to wait until we are answering questions?

Dr. Whitehead (Principal Science Adviser, Science Secretariat): I think I would prefer to respond to questions.

Hon. Mr. Drury: Mr. Chairman, there is one aspect which perhaps you might invite Dr. Gaudry to speak on, and that is how this fits into the views of the Science Council on Canadian activities in aerospace.

The Chairman: Thank you very much, Mr. Drury. At your suggestion I would like now to introduce Dr. Gaudry.

It is a great pleasure for me to welcome you, Dr. Gaudry, in your dual role as Vice Chairman of the Science Council of Canada and Rector of the University of Montreal.

I well remember the happy times when we were colleagues at Laval University. Even though we belonged to fields of study which were quite different, we were reunited at one point in our lives since we both left Laval University at the same time. I also remember that we called on the Rector of the University one after the other at that time to inform him of our respective decisions to leave.

Dr. Gaudry was not able to be with us when the Science Council made its initial presentation, because, as I understand, he was at that time in Europe.

Dr. Roger Gaudry (Rector, University of Montreal): That is right.

The Chairman: So you can see that the university rectors and presidents do travel, too. But we are certainly very happy to have him with us today, and without any further introduction I will ask Dr. Gaudry to make his initial presentation.

Dr. Gaudry: Thank you, Mr. Chairman. With your permission, I will speak in English, in case there are people in Ottawa who are still not bilingual.

What I have to say will be brief. I am here, of course, in my capacity as Vice Chairman of the Science Council. I only want to say a few words about where this satellite communications program fits into the over-all problem of space research and development in Canada.

The Science Council has been deeply interested in, first of all, the work of the Chapman Committee, which reported on space research in Canada, and, in July of 1967, the Science Council issued its Report No. 1, which you have in front of you: "A Space Program for Canada".

In this "Space Program for Canada", if you look at page 15, you will see a map of Canada which gives an idea of the places in Canada where some space work is being done, and what was in the year 1965-66 the rough expenditure in each place for space research.

So you may see that some money was being spent on space research in many areas of Canada. It was quite broadly distributed, with, of course, a very special emphasis on Churchill, were by far the largest amount was being spent, and on Toronto and Winnipeg. There is also Ottawa and Quebec, but I am not going to go into the details of what is being done everywhere. This is, I think, well described in the report, but I just what to point out the fact that space work is being done all over Canada, and that the space program that the Science Council sees for Canada includes a number of aspects, only one of which is satellite communications. In other words, I would not like you to infer or to understand that the satellite communications program is the only area of space in which the Science Council feels they should be engaged, and it is not only in that light that I want to talk today. I want to let you know that we feel that Canada needs a space agency to look into all the aspects of space work and not only satellite communications.

This suggested space agency is also described in the recommendations included in the space program for Canada which you have in front of you. I think, Mr. Chairman, that is all I want to say for the time being. I just wanted to put it into the proper framework of satellite communications vis-à-vis the space program.

The Chairman: Thank you very much, Dr. Gaudry. Are there any of our guests today who would like to add any comments? Dr. Solandt?

Dr. O. M. Solandt, Chairman, Science Council of Canada: I might just amplify a little on what Dr. Gaudry said. In space research and development man has already developed for the first time a new kind of capability. In the past when we have made complicated machines we have been willing to have statistical reliability. If you built 1,000 machines and 990 of them worked, you thought you had done extremely well. But when you get into the satellite area where you only build a very few, reliability has to be complete, and as in the case of the Alouette satellite we have demonstrated our ability to cope with this completely new kind of systems problem by being able to design and build a very complex system that works the first time and continues to work.

This is a highly complex—I was going to say skill, but it is not one skill, it is a whole series of skills developed by a lot of different people, and we in Canada have over the years developed these skills. The beginnings go back to the work on the Velvet Glove.

Over the years Canada has spent a good many tens of millions of dollars in space apparatus and research and related work on missiles, particularly in the defence field. A great deal of this money has gone into the training of this team of people capable of understanding and coping with this completely new kind of technology. The people are physically mainly in the Defence Research establishment here in Ottawa and the Canadian Army Research and Development establishment in Valcartier outside of Quebec City. These are the resources that Canada has in this field. In addition there are quite a few in National Research Council and quite a lot in industry.

Now, as we see it, the problem of planning a space program for Canada is to start with this very important resource of people and to use them as wisely as possible, and to my mind the principal argument for forming a space agency at least at the same time as the space communications satellite corporation or even before is to be sure that you have a national plan for using these people rather than having them all diverted towards the communications satellite which might happen if there was no organized space program when it begins. In saying this I want to make it clear that I am not suggesting that the communications satellite is not the first priority in our program. Let me say it again, and without the double negative; I think the communications satellite program is top priority in our space program and as set out in the White Paper I think it is an excellent exposition of the problems and goes a long way towards suggesting solutions to most of those problems. I want to make it clear that the Science Council strongly supports this, but we want to try to go ahead with the other aspects of our space program which are going on now to make sure we get the best possible out of these resources.

I think I mentioned when I appeared before you before that several people in the United States have said that Canada is in fact the third most important country in the world in space research and development. At the time I expressed some modest skepticism about this, but I have looked it up more carefully since then and I think it is true. This is because we have this relatively small number of highly skilled people—there are probably not more than 50 people in this group wherein resides collectively the skill that only two countries in the world have.

Speaking of skills, in this connection I might mention the one point that is not emphasized in the White Paper, and that is the very important chronology involved. We would hope to do most of the work of building our own communications satellite; we would not be able and we would not expect to be able to launch it; certainly not in the early ones because launching is a very costly operation, but we would expect to be able to control our own satellite when it is in orbit, and as described in the White Paper the control of a satellite in orbit is a very complicated job and one which will limit the operational life of the satellite. We have got to start very quickly to learn how to manage this control. We have a great deal of background in the building of satellites; we won't be doing the launching ourselves, but we need background in the control. This is one of the technical things that needs high priority with the space program in general and with the communications satellite program in particular.

The Chairman: Thank you, Dr. Solandt. Now I will ask Senator Leonard to initiate the discussion.

Senator Leonard: Mr. Minister, I am very happy to be able to call you that still; the first question is one that naturally rises to my mind. What will be the cost of the achievement of the four channel satellite? What is the estimated cost? I realize the figure must of necessity be a rough one.

Hon. Mr. Drury: Well, senator, I draw your attention to page 44 in the White Paper which discusses the cost of the satellite, the launching and the ground stations. The eventual cost will depend on the configuration which is decided on as being the best. But at page 44, at the top of the page, you will see the suggestion is made that the initial system might well have two terminals of the first type, that is the large terminals, five of the second type and up to 30 of the third type, which are the very small terminals.

Present rough estimates would indicate costs in the region of $3 to 5 million, $1 to 2 million and $100,000, respectively, for the three types of terminal. The numbers and costs would only be determined accurately as the design of the system progressed. A tracking, telemetry and command facility would also be required to keep the satellites in position and to monitor their performance. This facility could be an integral part of one or two of the main stations, resulting in an additional cost of those stations of approximately $1 to 2 million.

The total, overall cost for the space segment—this is the satellite itself—would be between $40 million and $75 million for three satellites; and the additional cost of launching and ground stations of the order of $50 million to $60 million, giving a total of something like $90 million to $120 million for the whole thing, depending on the configuration.

I may say that contracts have been let to two manufacturing consortia to do studies on the design and the cost perameters in connection with both the satellite itself and the ground stations, and we should have a much more accurate picture of the kind of options that are open and what the relevant costs would be in about six months' time.

Senator Leonard: Thank you.

Going now to the matter of international law, my understanding is that there is really no international law on this subject of the use of space, and that it is purely dependent upon any international agreement which may be reached, so that from a purely legal standpoint we can put a satellite over the Equator—is that the situation?—and use any of the channels that are now available by international agreement?

Hon. Mr. Drury: The physical space is not a problem at all. Obviously, at 23,000 miles away a vehicle which, say, cannot be more than 10 feet in diameter is not going to crowd things very much.

The limiting factor is the frequencies for receiving and re-broadcasting, and by international agreement these are now allocated by the International Telecommunications Union. But in the sense that law is an agreement enforceable by a system of sanctions, there is no law; there is agreement.

Senator Leonard: But that agreement deals purely with the channels?

Hon. Mr. Drury: With the frequencies.

Senator Leonard: With the frequencies?

Hon. Mr. Drury: Yes.

Senator Leonard: And at the present time there are at least four open to us?

Hon. Mr. Drury: Well, for this particular purpose, in this particular area, there are at the moment no other competitors.

Senator Leonard: And no agreement as to the use of them?

Hon. Mr. Drury: No, there are no other competitors. When you say "open to us," there is an unlimited range open to us for this now. How long it will obtain, I do not know, but others are interested.

Senator Leonard: So, if we occupy it, we have at least the possession, it being nine points of the law.

Then my next question is as to the satellites. Have we more than one Alouette satellite in space now?

Dr. Whitehead: We have two still operating—one launched a little over five years ago, and the other a little over two years ago.

Senator Leonard: Of course, these are in elliptical orbit?

Dr. Whitehead: One is in a circular orbit and the other is in an elliptical orbit, but both are in low orbits, moving quite quickly, at a $1\frac{1}{2}$ hours to two hours period of orbit.

Senator Leonard: Why is there greater difficulty in putting a communication satellite into orbit than there has been with respect to Alouette?

Dr. Whitehead: It is more difficult on two grounds: first, because the orbit, in order to achieve synchronism, that is a stationary orbit, is at a fixed altitude of 22,300 miles, which is very much higher than the orbits of Alouette; and, secondly, the corrections required to place it in a synchronized orbit over the Equator are somewhat more complex.

Senator Leonard: The next question: Where would HARP fit in here, if it does at all—or is HARP now gone to the University of Sussex; or are the personnel available, or is there any place in this for HARP?

Hon. Mr. Drury: The HARP project is designed to launch a smaller vehicle than we could possibly, with the present state of technology, design into a communications satellite of this character. You just could not use the

HARP technique for launching these; and HARP is basically a gun-launching technique.

Senator Leonard: That answers that.

My last question: I presume that the position of the CBC would be purely as a customer of the corporation you visualize for the creation of the satellite?

Hon. Mr. Drury: That is the present plan. One should make this clear that the satellite corporation will be merely a carrier of information, not a generator, in any sense of the word.

Senator Leonard: The CBC would not be in the position of a part owner or manager or director?

Hon. Mr. Drury: That is not presently planned, sir.

Senator Carter: You mentioned the problem of the limited number of channels. Actually, how many channels or frequencies, rather, are available? You said there are no competitors for this, but is there an unlimited number—100, 50, 20—how many would there be?

Dr. Whitehead: Twelve, at the present time.

Senator Carter: And how many frequencies?

Dr. Whitehead: That is 12 frequencies.

Senator Carter: Is there a similar problem with respect to orbital position for a synchronous satellite? Is there any number of positions you can use?

Dr. Whitehead: There is a limit, not a physical limit, for the reasons Mr. Drury said. There is plenty of room for thousands —indeed millions of them; but there is a limit due to the limitations of antenna beams and, therefore, interference between the users of the various satellites on the same frequencies. It is necessary to discriminate by means of a narrow beam and, of course, the beam from the ground antenna is narrower the larger the ground antenna; and there is a very real limitation to the size of the ground antenna, and a quite firm limitation to the size of the satellite antenna itself. These factors come in very heavily, and the cost of the ground station is extremely dependent on the size of the ground antenna.

Senator Carter: If we started out with two synchronous satellites and we set up a number of ground stations to link with them, and if we expand that two to, say, four or six, would that reduce the number of land stations or would it multiply it?

Dr. Whitehead: This is a very difficult system problem to answer simply, because the answer depends more on the sharing of frequency channels between the satellites. You could, of course, put up two satellites, each carrying four channels, so they would then use eight channels of the 12; but if you put up two twelve-channel satellites, each belonging to Canada, it would be necessary to separate them by the same amount we would have to separate from, say, a U.S. or South American satellite which would also be over the Equator. At the moment, that is approximately 6 degrees of longitude.

Senator Carter: Mr. Drury, you said something about our going into this in a modest way because we do not want to make obsolete the investment that we have already in communications systems. What will this kind of system do to the trans-Atlantic cable? Will it eventually cause the phasing out of the cable, or will there be still a use for it, do you think?

Hon. Mr. Drury: The trans-Atlantic cable provides an alternative means of communication which perhaps one would want to have always as a back-up. I do not think that the trans-Atlantic cable made obsolete the trans-Atlantic radio. They both have their particular uses. I do not think this would render useless either the trans-Atlantic cable or the trans-Atlantic radio telephone system.

Senator Carter: We have now a number of trans-Atlantic cables, and the newer ones have a large number of channels as compared to the original. Would the effect be that nobody would invest any more in trans-Atlantic cables because...

Hon. Mr. Drury: Well, this is really another field. What we are looking at here is the domestic communications satellite, and this will in no way compete with trans-Atlantic or trans-Pacific or even trans-border communications.

Senator Carter: Will there be no telephone frequencies?

Hon. Mr. Drury: There will, but only from Canada to Canada.

Senator Carter: I see.

Hon. Mr. Drury: There will be additional international communications satellites put up by INTELSAT of which Canada is a part owner, and they will be competing with the trans-Atlantic cables.

Senator Carter: Yes, but I was not thinking of our own in particular, but satellites in general. What will be their ultimate effect on present systems?

Hon. Mr. Drury: It will not be too long before it will be cheaper to launch a satellite and communicate by satellite on the trans-Atlantic span than it will be to lay another trans-Atlantic cable.

Dr. Whitehead: Yes, I think cost is a very important factor, but for a long time we would regard the various systems as being complementary. There are different considerations that apply to different parts of the system. For instance, the delay due to the time taken by the signal to travel up to 22,300 miles and then back again is appreciable, and it can be noticed in a telephone conversation, and this fact alone would introduce a little reluctance in respect of transmitting telephone conversations by way of satellite while there is a terrestrial system in which there is no delay. The result is less pleasant than that achieved by the performance of the ground system. So, there will be a redistribution of traffic as satellite systems come in, and we can foresee, at least for the time being, that a growth will occur in the satellite systems, and some redistribution will take place to utilize to the full the existing terrestrial systems.

Dr. Solandt: I should like to make the point that what Dr. Whitehead has just said about the time delay is an important factor operating against the use of satellites for direct voice communication. You do not notice it while watching television because you are not talking back, and the same applies to data transmission. There are communications companies within Canada which will, when satellite communications are in operation and where possible, route their conversations one way by the satellite and the other way by an adjacent land line, so that the two systems will be closely interlinked, and that will be done for this sound technical reason.

I might just enter a little technical point here. We are talking glibly of channels. These are television channels, each one of which will carry about 600 voice circuits, so what we are calling a channel now is not what used to be a channel a few years ago. It is six times as big. For instance, each one of the transcontinental microwave systems in service now would have a capacity not any bigger than a four-channel satellite. I just want to mention this in order to put into perspective the kind of capacity we are talking about.

Senator Carter: Then, looking to the future, do you think there is any likelihood of there being another kind of satellite that would employ laser beams that would render this kind of system obsolete? Is that a possibility?

Professor G. N. Patterson, Professor of Fluid Physics; Director, Institute for Aerospace Studies, University of Toronto: I am not sure that I am going to use the term you are, but when you use the term "another satellite" I want to point out that a communications satellite should not be the only satellite. Canada should be interested in satellite technology, and the various aspects of it in relation to the needs.

In the very near future—two or three years from now—the navigational facilities over the north Atlantic are going to be saturated, and the replacement of these by existing methods is not at all feasible. The obvious answer to this is to set up a navigational satellite which will be used for air traffic control. This will provide a very important means of controlling safety. The satellite will determine solar radiation effects from the sun of the SST, and it will look at turbulence levels and storm centers. It will do more. It will optimize the flight paths of the aircraft. The airline companies that use the satellite for flight purposes will do so at less cost, and will operate more efficiently than the airline that does not. This has to be a synchronous satellite, and as far as I know this has not been given any consideration by Canada at all.

This gets back to the Science Council's point of view that we should be talking about the whole space program and satellite technology, and how it applies to this country.

I should like to mention computer interconnection. Is this going to be done by satellite? There are also satellites for earth resources, military surveillance and deployment, and ground transportation and control.

I do not think anybody in this country has taken a look at the fact that the satellite can unsnarl traffic jams. The technology for doing this exists.

Let me speak for the universities. There are right now many objectives and concepts, and the universities just do not know where they are going.

Senator Aird: I have one brief question, Mr. Chairman. At page 64 of the White Paper, Mr. Minister, the example given is that of six television equivalent channels. While speaking you gave the option of four or twelve. I wondered whether there had been a change in thinking since the preparation of this. I assume that this is an example only. On the other hand, it does have a quite wide implication if the thinking has changed.

Hon. Mr. Drury: Well, the breakoff point in the building and launching cost of these devices is from zero to four, and then from four to twelve, and twelve is the maximum. These are all the channels there are. Now, it would be cheaper, presumably, to build a six-channel satellite than it would to build a twelve channel satellite, because there is less hardware in it. On the other hand, the launching costs are the same, and the launching costs are a substantial element in the total cost. If you are going to launch a satellite anyway then it might be as well to launch one that has built into it the additional channels, even though they are not going to be used at the outset. It is not quite clear at the present time as to how many channels is the optimum number we should have. It is quite clear that the Canadian Broadcasting Corporation will require at least one channel for English and one channel for French, which accounts for two. They may well want a second channel in English, which will account for three, and which will leave then only one available on the four-scheme for the telecommunications companies—the 600 voice circuits or their equivalent, which the other channel would represent—and there would be nothing on this basis for an independent television network, although at the moment I must confess that their needs in this field do not seem to be very immediate. One could envisage a place for six channels at the present time, but frankly I do not know the answer to this. Perhaps you can be more precise, Dr. Whitehead.

Dr. Whitehead: Even the dividing line between what you might call the small launch and the large launch, in which there are two or three major factors in cost, many millions of dollars, in terms of channels is not known until design studies progress a little way. It might be that a four-channel is the biggest that can be launched in the small form of launch. It might be that with better technology five, six or possibly even seven channels could be compressed into the smaller configuration satellite with a relatively cheap launch. This is one of the considerations. This, of course, has to be balanced against the customer's requirements, the demand for the number of channels.

Senator Aird: So in effect the minimal option is four?

Dr. Whitehead: Yes, and the maximum twelve because of the current availability of frequencies, and it could lie anywhere in this range.

The Chairman: Just to follow up Senator Aird's question and your comment, Mr. Minister, I was rather under the impression that there were some concrete proposals before the former BBG from the private sector of broadcasting. I have just got from you the impression that these were not projects for the immediate future.

Hon. Mr. Drury: There was a proposal put forward by a consortium of the Power Corporation and Niagara Television, the object of which was to establish an independent Canadian television network. This, however, was not based on any profound technological studies and represented rather more a proposal to get into competition with the current microwave network.

Senator Desruisseaux: I was not going to speak about this because I presented a brief for Niagara Television and the Power Corporation before the Board of Broadcast Governors in September, 1966. However, although I bypass most of the questions I would normally have in mind out of deference, there are three points I should like to clarify on the general situation. First, what is the life of a satellite in space? Is a satellite not very low in cost compared with what it will bring in in revenue? My third question is this. If we have a satellite in space, assuming that we will, and the services are being rendered, what becomes of the position of CATV? Can they connect direct or will they have to be regulated? Otherwise our local regional television stations might suffer to some extent because of the facilities being brought directly to CATV by means of the land stations, directly to the CATV amplifiers.

Hon. Mr. Drury: Could I ask Dr. Whitehead to answer the first two? First, what is the life of a satellite?

Dr. Whitehead: The life of the satellite is a factor that is really designed as a part of the compromise in getting the size down for the launch. If the design is properly done, as presently considered the life of the satellite would be limited by the amount of gas carried to make the continual minor corrections to restore the satellite in drifting from its stationary position, which corrections are always necessary because of natural changes. It is estimated an optimum design would give a life of about five years. Possibly the components of the satellite operation—the Solar cells, which are one limiting factor—would last a little longer than that. Presently five or six years is a good guess. A better figure would be obtained from the initial study.

Hon. Mr. Drury: Secondly, is this not a highly profitable operation? Perhaps I should try to answer that. I have given you some idea of the costs, the order of magnitude of the costs. It is estimated that these costs related to the kind of service this satellite can provide will compare favourably with the current charges for microwave transmission. They will not be a small fraction of current charges, nor will they be very much larger, but they will compare favourably with them. It is difficult to work all these costs out of the current microwave system because the costing of the elements is arbitrary. As you will understand, it is a bit like calculating overheads in the railway. It can be made profitable or made a loser merely by juggling figures around in the account books. I think this is one reason, because of possible lower costs in the future operations, why the private communicating operators in Canada would like to be shareholders in this company.

The third question related to CATV. The satellite will merely provide communication from one large ground station transmitting to another relatively large station on the ground receiving. The cost of a receiving station, as suggested in the White Paper, will be something of the order of $100,000, just for the station itself, and then onward transmission or re-broadcast from this station will be needed.

The CATV operates in areas where the population is relatively dense. You do not have CATV in Yellowknife, Coppermine, Frobisher, or such places. In most of the areas in which CATV is in operation there is already, as you will see from this snakelike chart in the booklet you have, a microwave system in operation; they are already served by microwave. Where this system will offer an advantage to broadcasting is up in the sparse areas where it would be very expensive indeed to construct a microwave link over a long distance with no population in between. I am not sure if I have answered your question.

Senator Desruisseaux: To be truthful, not fully, Mr. Minister, because on one or two occasions we have been given information that in the case of CATV transmission could eventually be made with some improvements in the technicalities of amplifying directly from the station, that instead of two broadcasting stations we could have two CATV centres, and then it would be farmed out to their subscribers.

The Chairman: You mean directly from the satellite?

Senator Desruisseaux: Not directly from the satellite to the land station but from the land station to the CATV receiving station, which is normally a receiver. The information was that the amplification was nothing to worry about, the arrangement was nothing to worry about to provide it. The point I really wanted to make and put on the record was that, if this was to be considered as a feasibility, it would imply, in my views at least, that the CATV arrangement would have to be regulated so that it would help the others and not be in a way of competing.

The Chairman: I am sure this will be noted by our future legislators.

Senator Phillips (Prince): My first question is not based on the White Paper but rather on a CBC news broadcast. I wonder if it could have been an influence on the broadcast, Mr. Chairman, as I notice in a recent CBC feature it is rather hard to find the minister who is now appearing before us—and I think your influence trickled into the CBC and they sort of kept it under control. The broadcast emphasized that all Canadians of the two official languages would be able to receive programs in their own language. I was rather pleased with this aspect from the point of view that I received numerous complaints from various groups that they had difficulties in obtaining broadcasts in their own language. I am thinking particularly of the Gaspé area where there are alternate programs—so much time in French and so much time in English—and then there is the question of prime time, as to which is going to be in prime time.

The Chairman: And geography?

Senator Phillips (Prince): I presume, Mr. Minister that I interpret the CBC broadcast correctly, that all Canadians regardless of time will be able to receive a broadcast in their own language?

Hon. Mr. Drury: The ability to receive broadcasts in each of the two official languages depends on the location and availability of the broadcast stations. There are some areas in Canada where the Canadian Broadcasting Corporation does not have two transmitters. The satellite will not make possible the direct reception by individuals of broadcasts: they will have to come down to a ground station and be rebroadcast in the normal broadcast channel by our broadcast to users. This will make available to any place in Canada a program in French and a program in English which can be rebroadcast. It will be up to the CBC to establish the rebroadcast facilities but they will now be able to do this without the necessity of expenditures on land lines linking up to the main communications networks.

Senator Phillips (Prince): That is, CBC or private enterprise?

Hon. Mr. Drury: Or private enterprise.

Senator Phillips (Prince): My next question concerns the launching. Canada is not in a position to launch a satellite and of course will have to depend on our neighbour for this.

Hon. Mr. Drury: We also been looking at the possibilities of a European launch.

Senator Phillips (Prince): Regardless of who conducts the launch, Canada will still have complete control of the programs that are received from the satellite?

Hon. Mr. Drury: That is correct.

Senator Phillips (Prince): My next question is based on the testimony of previous witnesses before the committee. Some of these have emphasized that Canada should in its research program attempt research in fields in which we have established a certain excellence. How do we stand in communication research as compared with other nations? I presume we are very well to the forefront?

Hon. Mr. Drury: I think it was Dr. Solandt who pointed out that we are scored third in this field in the world. In communications, we are pretty close to third, too.

Dr. Solandt: In the past nine years—

Dr. Whitehead: It is one of Canada's strongest lines of research.

Senator Phillips (Prince): I am concerned with the map of Canada which is on page 15 of the Science Council of Canada Report No. 1, on "A Space Program for Canada". It outlines the expenditures for research. I need not seek to remind you that the Senate is established on a regional basis—I will not argue on this—but while you were kind enough to put in the province which I represent, there is nothing for that province. Also, if I add up the total for the Atlantic Provinces, although I am not good at addition, it comes to something less than $1 million for the four Atlantic Provinces. Compared with the rest of Canada, the Province of Quebec receives something close to $16 million. It would be unfair of me to suggest that you represent the Province of Quebec, sir; I will not do that. However, I would like to know why the Atlantic Provinces have received such a small share of the total expenditure.

Hon. Mr. Drury: Perhaps one should look at these little blocks in relation to the physical facilities. Manitoba, theoretically does very well in this field because there is the Churchill range for rocket launching and this calls for a fairly large continuous annual expenditure. This is used internationally.

In Winnipeg in the southern part of Manitoba there is a large manufacturing organization which produces the Black Brant rockets and this accounts for virtually all the expenditure in Manitoba.

In Quebec, most of the work on the Alouette satellite was done by RCA Victor in Montreal and by the defence research establishment at Jacques Cartier outside Quebec which accounts for a large proportion of the so-called Quebec money. It is in relation to these facilities which happen to be there.

In the Maritimes, probably most of the station research work was in connection with Mill Village, which is the receiving station for INTELSAT communications and in the location of the expenditures is in relation to the facilities.

Relatively little of this is in academic institutions, it is most either in large manufacturing concerns or in a government laboratories. As Senator Leonard mentioned, the amount of money made available to academic institutions in this program is relatively small. I suppose in relation to the academic institutions the emphasis which the universities in each province place on space research will determine the degree to which they attract financial support for space research, and I do not think that there has been in the Maritime universities any very substantial interest in space research.

Senator Phillips (Prince): Mr. Minister, I was intrigued by the statement of Professor Patterson, who mentioned the satellite controlling of air traffic over the Atlantic. I just want to put in a plug here, if I may. The major portion of the trans-Atlantic traffic will pass over the Atlantic provinces, and in any future program I hope you will bear that in mind, Mr. Minister.

That is all for now, Mr. Chairman.

The Chairman: You will have the causeway, though.

Senator Phillips (Prince): We have been looking for that for something like 11 years now. I have lost interest in it, Mr. Chairman.

Dr. Solandt: May I just comment on that, Mr. Chairman? Probably the most highly decentralized research and develoment program that we have in Canada is the space research program. You can see from the map on page 15 that it is very widely distributed, which I think is excellent.

Senator Phillips (Prince): Dr. Solandt, in that regard, perhaps you could spend your holidays in the Atlantic provinces and familiarize yourself with the situation there.

Dr. Solandt: As I emphasized before, Mr. Chairman, this problem of geographic distribution is an important one, but you cannot take each program and say that you will spread it evenly. The Atlantic provinces, for instance, have the major oceanographic work in the country. Now, you would not argue that Manitoba should have a share of it and Saskatchewan and Alberta a share. It is divided between British Columbia and Nova Scotia. The same thing applies to fisheries research. In Halifax the National Research Council has a lab which is interested in the lot of the Maritime provinces. I think we have to look at the balance of our total program and try to put each element where it is most effective.

Senator Phillips (Prince): I will do a study on the balance some time, doctor.

Senator Grosart: What has Prince Edward Island got?

Senator Phillips (Prince): Nothing. We have not even got the causeway, senator.

The Chairman: Senator Lang, do you have any more questions?

Senator Lang: Yes. I should say by way of preamble that I come to this satellite matter completely cold, Mr. Minister. In the questions directed earlier I did not feel that I got an adequate grasp of what government policy there may be now in respect to the use of this method of transmission. I am always a bit concerned about these things because I feel that anyone who has control of a satellite like this has a very high measure of control over this media oriented world of ours. During the recess I was looking at page 36 of the booklet and in the second paragraph I see these words:

> "It would provide telephone service to many of these same areas, and it would supplement the transmission of television, telephone, and data service over the long distances now covered by the microwave networks. These measures would enable the Government to take major steps in protecting and strengthening Canada's cultural heritage."

I presume, Mr. Chairman, that that word "government" refers to the federal government. Now the use of the word "government" in there concerns me. My interpretation of Canada's cultural heritage is, I think, pretty well synonymous with the government's interpretation. But governments change and the satellite will still be up there. Therefore, Mr. Minister, I would like it if you would amplify further what distinctions you may have with regard to the control of this machine which will be putting down into hitherto barren areas of Canada a message from the skies.

Hon. Mr. Drury: Well, the control of the common carrier, and that is what this really is, perhaps falls under three heads: first of all there is ownership, and to the extent that ownership confers control on a large existing corporation, this will be partly government and partly private.

Senator Lang: In any particular ratio?

Hon. Mr. Drury: The ratio has not yet been determined. But one would want to have a maximum infusion of a private initiative with, however, sufficient influence on the part of government to see that the public interest was preserved. What that balance is I cannot at the moment tell you.

The second aspect of control is in terms of regulation. The regulating agency will presumably be the Canadian Transportation Commission who have some degree of regulation over tele-communications and may in future or may not—I am not sure—have more. The government also has control over the content of the broadcast transmissions through the B.B.G. and to some degree through the government corporation, the Canadian Broadcasting Corporation.

Senator Grosart: You say the government has control?

Hon. Mr. Drury: Perhaps that is not the right term.

The Chairman: I believe Mr. Drury was never responsible before Parliament for the C.B.C. I was.

Hon. Mr. Drury: That is correct. It is probably only through the Canadian Transportation Commission that this control could be exercised. I think in relation to the B.B.G. I use the word "influence" rather than control.

The third aspect of this is in relation to the technological development. This is the possession of knowledge within the government that is as great as that within the Corporation and which enables the government at least to know, and where desirable to influence the future direction of development of this particular system of communications. Now perhaps in the long run the latter is the most important. The most direct, obviously, is regulation through the Canadian Transportation Commission, and of concern, but perhaps not so important, is this question of ownership. As was mentioned, the Government of Canada owns the Canadian Broadcasting Corporation, but there have been times, I think, when there has been evidence that this does not produce much control. This would indicate that ownership is not necessarily the controlling agency. I think what this sentence here has reference to is: if the satellite program is proceeded with it will enable steps to be taken to broadcast to hitherto economically inaccessible areas of Canada television programs in both languages. That is really what is meant by this—the major steps that will be possible.

Senator Lang: The difficulty of the common carrier concept of course is the limitation of channels imposed by this system. I think that is basically what concerns me. I think if you put up the satellite there will be more channels available theoretically than on the common carrier concept, but I am afraid the limitations imposed by this system are liable to shift the powers, even of the B.B.G., into the hands of the Department of Transport over broadcast content.

Hon. Mr. Drury: Well, 12 channels, which was the ultimate, still represents an excess over current needs. There will always be the possibility of further growth. As Dr. Whitehead pointed out, if we can technologically make these satellites rather more discriminating, one can give them specific purposes covering specific areas and thereby increase the number of available channels. This also can be supplemented by an increase in the land line or microwave system. If this were to be an exclusive system of television transmission, what you say would be true, but it won't be either initially or eventually. At any rate, I don't think so.

Senator Lang: Dr. Whitehead, as a matter of curiosity why did the Russians put up this seriatim system of satellites which would appear to me to be probably more expensive.

Dr. Whitehead: It is cheaper in some ways and more expensive in others. They are easier on the whole to launch, need less equipment for guidance into orbit and so on. On the other hand, the ground stations become more complicated because they have to follow the satellite as it moves across. They have to be able to detect where it is, lock on to it and follow, and this represents quite a lot of equipment on the ground. It is absolutely prohibitive compared to a small ground station such as we mentioned for the Canadian North, in the order of a few tens of thousands of dollars or $100,000; the minimum ground station would be very much more expensive for a non stationary satellite.

Senator Grosart: Mr. Minister, I am not clear on the thesis in the White Paper and your statement about the urgency of preempting frequencies. International lawyers and economists on international agreements in respect of space sharing are one of the outstanding developments in the field of international law. You seem to suggest these frequencies are up for grabs, that if we do not get in here, somebody else is going to grab them. Is this so, that we are not at a point where there is some international agreement that there are certain frequencies allocated or available to us, and that nobody else can pre-empt?

Hon. Mr. Drury: No, I do not think we have reached that point yet. There is general agreement that there will be consultation amongst the members of the ITU before a frequency is taken into use. It is difficult, however, for the ITU or its members to refuse the allocation of a frequency to a member which is ready and able to use it, as against another member who says, "Well, I cannot use it now, but I might at some date in the distant future want it."

Senator Grosart: There are 20 members of the ITU, is that correct, 20 member nations?

Hon. Mr. Drury: I do not know.

Mr. Flynn: All the nations of the world.

Hon. Mr. Drury: I thought it was certainly a lot wider than 20.

Senator Grosart: I have that figure in mind, but I may be wrong.

Mr. Flynn: Possibly you are thinking of INTELSAT.

Senator Grosart: Yes, there are 20 members of INTELSAT.

Hon. Mr. Drury: INTELSAT is a body which has also to apply to the ITU for a frequency allocation.

Senator Grosart: There is a statement here that some European communication satellites, and perhaps some United States ones, will very soon start to cover southern Canada. What is the implication of this?

Hon. Mr. Drury: I did not appreciate this suggestion in the White Paper. The prospects are for additional INTELSAT satellites which will carry on, not domestic but international communications. The European "Symphonie" again will be international rather than domestic, and some of these international satellites will broadcast so that their transmissions or their emissions will cover part of Canadian soil, either the west coast or the eastern part of Canada.

Senator Grosart: In view of the fact—unless I am mistaken—that unless they are picked up by ground stations they will not in any way affect reception, what is the significance of the word "cover"?

Hon. Mr. Drury: Well, the receiving station or the broadcast satellite emits a pencil beam which tends to fan out as it gets farther away. Eventually, starting from a pinpoint of the satellite, it will cover the whole of Canada.

The ground station has a pretty highly directional aerial—a sensitive dish—which is pointed at the satellite. If you have another satellite broadcasting on the same frequency, this kind of pencil beam within six degrees of arc, it will be picked up by this same dish and constitute interference with the signal from the main satellite to which you are beamed. One over the Atlantic broadcasting on the same frequency as one over the central Canada equatorial position will not interfere at all, although this dish for the Canadian receiving station could be turned so that it receives the INTELSAT one.

By "cover" I mean the broadcast from the satellite hits the earth, but unless we have a correctly oriented receiving apparatus it will not interfere or pick it up.

Senator Grosart: How far are we away from the day when there will be direct reception in homes from satellite broadcasts?

Hon. Mr. Drury: I will ask my "crystal ball", Dr. Whitehead, to answer that.

Dr. Whitehead: Ten years has been mentioned. It depends on the pressure: really anything is possible if enough facilities are put towards it.

The problem here is providing adequate power in the satellite itself to transmit a very much stronger signal, which makes for a very big satellite and an expensive launch. Therefore, the decision, when it comes, will be likely to involve really rather a big system, and would be very much a deliberate political decision on the part of the country which made it, I think.

Senator Grosart: Is the U.S.S.R., by agreement or otherwise, extending its reception area into other countries—particularly what we call the iron curtain countries?

Dr. Whitehead: I have no knowledge of that.

Mr. Flynn, Science Adviser to Science Secretariat: The U.S.S.R. system is an international system, and it is open for any country to join the system which wishes to.

Senator Grosart: In other words, it will become a propaganda medium, or it could be.

Mr. Flynn: It could be.

Senator Grosart: And if it could be, it will be.

One other question, Mr. Minister...

Hon. Mr. Drury: Perhaps one should make a technical point here, that the Russian satellite merely retransmits what it receives and will relatively quickly get out sight, with a relatively low orbit, of the Russian transmitter, so the Russian transmitter could not use this satellite, for example, to communicate with Australia, on the other side of the globe.

Senator Grosart: It could with Poland and Czechoslovakia?

Hon. Mr. Drury: Yes.

Senator Grosart: And what we used to call Estonia, Lithuania, and so on?

Hon. Mr. Drury: Yes.

Senator Grosart: Getting back to the domestic scene, looking at the list of applicants, people who were ready or said they were ready, anyway, to jump into satellite communications in Canada, or very large commercial entities, could they not put up the $120 million? Does the Government have to be in this at all?

Hon. Mr. Drury: In purely dollar terms, perhaps the Government does not have to be in this at all, although it has not been established, certainly to date, that the financial resources would be available from the common carrier groups, and others.

Senator Grosart: It would look as though these entities, if they were able to get their returns on them, would be able to put up that money between them, which raises the question which I think is in the minds of quite a few of us, that the Government controls this. Political decisions being largely a matter of choice, are we going to choose between these people and the various telephone companies and all the people who will want to use it? Although you said that there was a capacity in excess of present demand I can, from reading the White Paper, add up in my mind twelve organizations which I think will be demanding a channel.

Hon. Mr. Drury: Well, this will supplement the current microwave system, and it would be my hope that the common carriers would be participating owners in this new system. If this is so, they will have, in a sense, a foot in both camps.

Senator Benidickson: Do you include the CNR?

Hon. Mr. Drury: The CNR, the CPR, and the telephone companies and possibly non-carrier people. The experience in the United States with COMSAT, which is their domestic satellite corporation—it is entirely privately owned—has been that the common carriers have tended rather to take over even though there was non-carrier participation in the ownership.

Senator Grosart: Do you anticipate a problem of a monopoly being created here if a group of commercial entities are co-owners with the Government? Is this going to shut out the competition, for instance, of an individual TV station?

Hon. Mr. Drury: I do not see this at all, no. The TV stations will have a choice between the current terrestrial networks and this.

Senator Grosart: But, in time, there will not be very much choice.

Hon. Mr. Drury: In time? I think there will clearly be for quite a long while yet. It may be that satellite communications will become vastly less expensive, and that the capital costs of the terrestrial systems will continue to rise, in which case the emphasis will shift to the satellite system. But, as Dr. Whitehead has pointed out, I do not see this displacement of the terrestrial systems in respect of particular purposes taking place for quite a long time to come.

Senator Grosart: Am I putting it correctly if I say that one of the purposes of Government participation in both ownership and control is to regulate this in the public interest?

Hon. Mr. Drury: That is correct.

The Chairman: I think that Senator Benidickson has a question.

Senator Benidickson: I am not a member of the committee, Mr. Chairman, but I thank you for your courtesy. First, may I pay tribute to the minister? I think that in the Department of Industry many worthwhile things have been done.

Senator Phillips (Prince): Now, now.

Senator Benidickson: This committee is considering science policy, and I think it should consider also the political implications...

Senator Grosart: It never does.

Senator Benidickson: You are the Minister of Industry, and Dr. Solandt is here, and I should like to say that I am concerned about the most effective way of getting a scientific advice through cabinet and through a minister. I should like to ask your views as to whether this is something that should be done through your department, or through the Prime Minister's office—a committee of the Privy Council? How can we get the utmost attention given to scientific assistance? Dr. Solandt has had great experience in this, and perhaps he could answer my question.

The Chairman: This is a loaded question, I think, but if you feel free to answer...

Senator Benidickson: I do not want it to be loaded at all. Dr. Solandt has given his services to...

The Chairman: But, as you say, this has political implications, and it involves a political judgment.

Senator Benidickson: That is why I say to Dr. Solandt: Do you think we should have a department of Government to deal with this, or do you think we can deal with it directly? Can we deal with it by avoiding the Privy Council and dealing with a ministry such as that over which Mr. Drury presides at the moment—although I know that within the next few days there might be changes.

Dr. Solandt: Well, I think that this is a natural for Mr. Drury.

The Chairman: Mr. Drury is involved now in cabinet making, so I suppose he might be the one to deal with this question.

Hon. Mr. Drury: I commend Dr. Solandt for his modesty. Basically your question is one of whether there should be a ministry of science or a ministry of technology.

Senator Benidickson: Yes, and I ask that question having regard to your experience in dealing with Parliament.

Hon. Mr. Drury: There is a lot to be said for it and a lot to be said against it. I suppose one might conclude that what is right at some time is wrong at another. But, research, in my view at any rate, should be regarded by every executive as an integral part of his day to day work. There is the danger that if there is established a ministry of technology or a ministry of science, that research —philosophical and in budgetary term—will be shoved off by all other departments of government on to this ministry because it is its responsibility. If this were to happen then I think it would represent a substantial loss to research and to science generally.

It has been my endeavour to get all ministers to accept the idea that an essential element in each of their administrative functions is a research element for which they are continuously responsible, and that this is not something to be left to somebody else. On the other hand, there is a distinct advantage in terms of making the best use of limited resources and providing a focus of interest in research in having a ministry or a department of science or technology.

I have at the moment no particularly strong views as to the necessity for a change at the moment. I think our greatest task—and I hope Dr. Solandt will agree with this—is that of stimulating rather more of this kind of preoccupation with or concern with research and technology in the manufacturing industry in Canada itself...

Senator Benidickson: You are talking now about industry?

Hon. Mr. Drury: Yes, manufacturing industry—than it is with either improving the quantity or quality of science within government and government departments. I am not sure that a department of science, or a department of science and technology, would be materially effective in doing this.

Senator Benidickson: I am glad to have that answer. May I ask Dr. Solandt: With respect to the important assignment given to you, and the exceptional talent with which you are associated, have you a criticism to make on what is being done in government? Can we help you more? What would you suggest? This is a question for Dr. Solandt.

Dr. Solandt: Mr. Chairman, I thank you for your very kind words, and I should like to say first that I completely support what Mr. Drury has said. I think that the most important single thing we need in Canada now in relation to the Government, the Senate and the House of Commons is a much greater interest in and understanding of science by members and senators. I feel that this committee is a major step forward just in opening up a channel of communication between the scientific community and the legislative bodies, and I hope this will continue and expand.

On the question of detailed organization, I agree strongly with Mr. Drury's view that it would be a pity to take research out of individual departments. We need research in most government departments and it should have a major place. It should not be just a sort of technical adjunct but should play a major role in the whole of their operations.

The real problem we face is one of coordinating the efforts of the research community and the scientific community throughout the country. As I see it, we are passing into a new phase now. In the past we first of all thought of science as something that scientists and universities did in their spare time because they preferred to do it rather than play golf. Then we began to see that it had some role in the economic field, particularly in industry, and especially in our case in primary industries and secondary manufacturing. Now I think we are beginning to see a greatly increased scope for science in the solution of the wide range of not just economic problems but social problems, the kind of thing Dr. Killian was talking about this morning. If we are going to do that, this changes the role of the federal Government particularly.

Senator Benidickson: Does it change the role of the Science Council?

Dr. Solandt: I am coming to that in a moment. It seems to me that the federal Government will be more and more concerned, not with the execution of research but the planning, co-ordinating and financing of research programs which will be widely spread throughout the scientific community, some by government, some in the universities and some particularly in industry. The role of the Science Council as I see it is to draw a map, to see how that should be done in a broad strategic way. You asked what we need to do the job better.

Senator Benidickson: No. I asked: are you reporting to the right source and are you getting results?

Dr. Solandt: These are two very difficult questions to answer. As you know, there was a great deal of discussion about where the Science Council should report. It was agreed that it had to report to a senior minister preferably to a minister who had no operating responsibilities for research himself. This is one reason why, for instance, the Science Council does not report to Mr. Drury. In fact, it is the only reason. It is because he is responsible for the National Research Council and many other research agencies, and other groups would say that it is not fair to have the minister looking after the budgets of part of the research organization being responsible for policy for the whole thing. It boiled down to reporting either to the Prime Minister or to the Department of Finance or the Treasury Board. I think the decision was first reached in the Glassco Commission Report, and later supported by Dr. Mackenzie, that it should report to the Prime Minister. This was a good arrangement in every way, except that the Prime Minister does seem to have other preoccupations! This was something we had not quite envisaged.

Senator Benidickson: Yes, but has not everybody? What is the best place to put your problems forward to?

Dr. Solandt: Well, it seems to me that we can pursue the present system, which is not working badly and which I think will work better as we get more expert at it. It has been slower than we would have liked, but the quality of what we have done has, I think, been satisfactory. As I say, everyone has been disappointed about the slowness at which we have gone, but this slowness has not been due to the failure of government to act on what we suggested, but to failure on our part to collect the information. We have probably been far too critical in getting data and making analyses, not working on incomplete data but rather getting it more complete, so our slowness is our own fault, but also because of lack of staff.

Senator Benidickson: Is the Government supporting you with staff?

Dr. Solandt: Yes and no. We have had difficulties. I think we have got over them now and I think we shall get the staff we need. We have been short of staff.

Senator Benidickson: You had a galaxy of people originally organized. Are they staying with their enthusiasm?

Dr. Solandt: Yes, I think the staff turnover has been almost nothing.

Senator Benidickson: I meant the composition of membership. I meant your original body, the galaxy of council membership.

Dr. Solandt: The council was appointed on the basis that they would serve for a three-year term once renewable. The first group of retirements are coming up this year. The first ones were appointed for two, three and four years to start with, so we have not had any significant turnover. We have had one death and two resignations.

Senator Benidickson: But we still have the prestige of all those people and their enthusiasm.

Senator Grosart: Could I ask a supplementary question arising out of the very interesting pros and cons of a ministry of science and technology given by Dr. Solandt. Admitting that the national climate is very difficult, is there any evidence that the establishment of a Ministry of Technology in the United Kingdom has lessened the research effort on a decentralized basis?

Dr. Solandt: I have not been in England for nearly a year to discuss at first hand what is going on. I am going over tomorrow. I would say that when I was there a year ago most of them were really quite unhappy with the arrangement. This, of course, was partly because it was very new and involved some tremendous rearrangement of structure in their research organization. I do not think their particular pattern is a good one to follow.

Naturally we have discussed amongst ourselves many hypothetical organizations. One that is a strong possibility—it is theoretical and I think you will all see the political difficulties of it—would be a ministry of science; that is, a minister with a very small staff which had no operating responsibilities for any research and was concerned only with co-ordinating research policy for the Government as a whole, ensuring that research was well represented in Cabinet discussions.

Senator Grosart: To what extent has the Treasury Board real control of the development of scientific projects?

The Chairman: Before you answer that, Dr. Solandt, would you allow me to excuse Mr. Drury, because he has received an urgent call and has to leave the committee at this stage. Before he leaves I should like to thank him very much for being with us for most of this afternoon during this troubled week. Thank you very much, Mr. Drury.

Hon. Mr. Drury: Thank you very much.

Senator Phillips (Prince): May we congratulate him, Mr. Chairman, on his new post?

Hon. Mr. Drury: If I may make one short answer. This depends on the Treasury Board. The classical concept of the board was—perhaps I should not say classical concept, but the way in which the board had come to function over a number of years was as a regulator in detail of Government operations but having very little influence on policy.

The endeavour has been made in the past few years to translate or reverse this function, to decentralize control over detail, to the department, and have the Treasury Board occupy itself rather more with co-ordination policy. It has been a view of the Board that research is important, that it should be an integral part of any government department's operations. To this extent, it does exercise some control. I suppose that in the event that there was too much emphasis being placed on research and not enough on results, there may be a rather negative, if you like, denial of this excess. But the Treasury Board in the past has not been much of a generator of new policies or new ideas: it is rather more a co-ordinator and controller than it is a generator.

Senator Grosart: But it would exercise a function in selecting priorities, by the very nature of its function.

Hon. Mr. Drury: In general priorities, that is correct.

Senator Grosart: And science policy priorities, too?

Hon. Mr. Drury: The priorities in respect to science are left as they properly should be, largely to the Science Council. Indeed, Dr. Solandt will agree that this is one of the main objects in establishing the Science Council, to set up a list of priorities, which I am quite sure the Treasury Board will be only too glad to observe.

Senator Benidickson: But, Mr. Drury, the Treasury Board, would analyze its expenditures in various categories and they would include the research and development expenditures of all departments and put them down in a list. They have it in their statement for the year. They would then decide overall, perhaps, what percentage was being given to research and development.

Hon. Mr. Drury: I do not think so, sir, if I may differ.

Senator Benidickson: You do not think so?

Hon. Mr. Drury: No.

Senator Yuzyk: May I ask a question which has a yes or no answer. Does the Treasury Board consult you?

Hon. Mr. Drury: Can I answer that a little longer—I had better go before this comes.

Dr. Solandt: The way we had this in operation, and I think it was beginning to work, was that the Science Council would try to outline broad strategic science policy. This takes the form of studying what kinds of research programs we ought to pursue and putting them in some order of priority and also trying to assess their general importance to the nation. When you get to a national level in science policy, you are concerned not just with what things are best to do in science but how the expenditure on research and development programs compares in importance with say expenditures on welfare programs, construction programs, or something like that. So it is not just a weighing of one scientific thing against another, but of trying to portray how important these scientific programs are to the nation as a whole.

We would visualize that we transmit that information, in reports to the Prime Minister, to the public and of course to the Treasury Board, and that the Treasury Board, if they are concerned about whether a particular program that they are asked to support fits into our strategy, it goes to the Science Secretariat in the Privy Council office. This they do pretty regularly, so that they get specific advice on specific programs. It is in consonance with the general views of the Council. Therefore, we have to be careful to keep the Science Council out of recommending on relatively specific programs: it has to handle the big ones which shape the policy that we ought to deal with.

Normally most of the programs dealt with by the Treasury Board are those dealing with broad policy advice that we give.

The Chairman: In the last few minutes we have gone a little out of order, if we consider the specific purpose in meeting this afternoon, which was to deal with a White Paper on communication satellites. As I said at the beginning, this was the main purpose, the purpose of this meeting. I am sure that these general questions which are put now to Dr. Solandt and the others will come back at our future meetings. We certainly will have the Treasury Board before us at some stage, in the second phase of our inquiry. As I said to Dr. Solandt when he first met with the committee, we certainly hope that the Science Council will come back before us at a later stage, to deal with more general questions about science policy and priorities, and especially when it will be issuing its next report on the main purposes of science policy, and also to discuss further the ideal organization for our science effort.

If there is no more questions on this specific item of business before us this afternoon, I would like very much to adjourn as quickly as possible.

Senator Yuzyk: Since I am last here, I have two questions and I think it should be very easy to answer them briefly. One question is on the capabilities of our receiving stations and the impact on television. Can our receiving stations tune in on frequencies, say, of the United States satellites or U.S.S.R. satellites, for the transmission of programs? And can they be transmitted in Canada readily? That is the first question.

Dr. Whitehead: A brief answer would be "no".

Senator Yuzyk: It is no?

Dr. Whitehead: There are complicated questions of agreements and so on but in general a Canadian ground station will be located or beamed on to our own satellite and only on to our own satellite and no other satellite will ever come within the beam.

Senator Yuzyk: But the U.S.S.R. can beam on our satellite, can it?

Dr. Whitehead: No.

Senator Yuzyk: It cannot. Well, that answers my question—but that is a possibility in the future, though, in the international sphere.

The only other question I have here is referring to our satellite in the system. It has been mentioned that other uses can be made of our satellite system than just for the purposes of television and that is something that the agency will be looking into, is that not right?

Dr. Whitehead: This would be the business of the communication satellite corporation.

Senator Yuzyk: What are some of the other uses, besides television?

Dr. Whitehead: Television, data handling, data transmission, computer connection.

Senator Grosart: Radio.

Dr. Whitehead: Radio is of course a simple one. Broadcast and FM.

Senator Thompson: I notice that Dr. Patterson had mentioned that there is no space research being done in the universities. I was concerned, because Dr. Solandt had said that this whole achievement is because a team of 50 people, able, trained, dedicated men, were engaged. I am just wondering if there should not be more emphasis given to universities in the training of young scientists in this field, in space research?

The Chairman: If you will allow me, I have a supplementary question with which you might deal at the same time, because it is directly related to the future conduct of our hearings. I wanted to ask if Dr. Solandt is aware of whether or not the Government has considered this special report on the space program for Canada at the moment?

Dr. Solandt: Yes. It was submitted to them about a year ago.

The Chairman: But no specific action has come out of it up to now?

Dr. Solandt: Well, it is a nice question whether action on the communications satellite can be attributed to this or not. It was under way before this report was put in.

The Chairman: I was just thinking that we might invite you and your people back at some future date to deal with this specific problem of the space program.

Dr. Solandt: This might be quite probative, because I think Professor Patterson might like to explain further. I think you misunderstood his statement, Senator Thompson. What he said, I think, was that universities did not have any coherent plan or know where they were going in space research. There is quite a bit of space research going on in universities, but there could well be more. I am sure Professor Patterson could give you a thumbnail sketch, if you wanted.

The Chairman: We will certainly try, Senator Thompson, to organize a meeting which would be specially devoted to this whole area of research.

Senator Benidickson: Professor Patterson might give that thumbnail observation right now.

Professor Patterson: I would simply add that there are perhaps three or four major space institutes in Canadian universities at the present time, as well as a great many programs being conducted by individual professors with their groups of students, and my point really was that, until we get a space agency and a national space program, universities will not know where they are going.

I could add to that by saying that the National Research Council's support of Canadian universities' rocket research is growing at an enormous pace right now because universities have got on their horse and are galloping off in all directions at the same time. There is no policy there, and we need some one to help us formulate one.

The Chairman: One last question.

Senator Phillips (Prince): Mr. Chairman, you have very effectively stifled my question by saying it does not deal with the White Paper, and, being very much aware of the hour, I do not propose that we should go into a discussion of it at this time. However, I was rather intrigued by the remark of Dr. Solandt to the effect that he felt that it was necessary to report to a senior cabinet minister. Bearing in mind that I consider all cabinet ministers equally responsible perhaps we could take it up at a later date.

Senator Lang: Mr. Chairman, I just wanted to ask Dr. Solandt whether Mr. McIntosh reports to him.

Dr. Solandt: No. He reports to Mr. Drury. He certainly does not report to the Science Council.

The Chairman: We want to thank our guests for appearing before us this afternoon and for all the time they have spent here, although I am rather afraid they will have to come back. You must have seen the interest of the members of the committee in this whole intriguing field, and the next time you are here I hope that we will be in a better position to devote more time to the space program.

Thank you very much.

The committee adjourned.

THE SENATE

EVIDENCE

Ottawa, Wednesday, April 24, 1968

A convocation of members of the Senate met this day at 3 p.m. to consider Science Policy.

Senator Allister Grosart (*Chairman*) in the Chair.

The Chairman: Honourable senators, Senator Lamontagne is unable to be here at this time, although we expect he may join us later this afternoon. In the meantime he has asked me to substitute for him. The intention is to carry on with the procedure established by him at our previous meetings.

We have a distinguished guest and witness again today, Dr. Richard R. Nelson, Economist of the Rand Corporation of California.

I might say to you, Dr. Nelson, that normally we have a much larger attendance than we have today, but with a federal election called there are other meetings going on for which there appears to have been a call for some latent brain power from the Senate. However, we have eight or nine senators and perhaps before the afternoon is out we will have more. I can say, looking at the senators who are present, that the cream of our crop is here.

Our procedure is that we will ask you to give us a general statement in line with the terms of reference that have been passed on to you and then we will call for questions and ask you to reply.

Honourable senators, you have Dr. Nelson's biography. You have heard a great deal about Ph.D.s in our meetings so far. Dr. Nelson is a Ph.D., a former Professor of Economics, and the co-author of the book, *Technology, Economic Growth and Public Policy*.

I would urge you all, if you have time, to read that book. It follows along the lines of our terms of reference. It almost reads like the kind of report we would be making. The last chapter, chapter 9, which is entitled "Public Policy Proposals" deals with matters that we have discussed in our previous meetings.

Senator McGrand: Is that book available in the Parliamentary Library?

The Chairman: Yes, it is available. You have the digest of it prepared by our staff, but I would suggest to you that of all the books I have seen so far on our subject, this is the one that I find, as a layman, easiest to absorb. Without any further words, Dr. Nelson, at this time I would ask you to let us have the benefit of your wisdom on this subject.

Dr. Richard R. Nelson, Economist of the Rand Corporation of California: Thank you very much for inviting me here. I consider it an honour to be here and hope that this session may be fruitful. I would like to disclaim all responsibility for the environment and the urgency that seems to surround Ottawa these last couple of days. I certainly did not intend that my visit should trigger a general election. I hope very much that our session will be informal.

I would like to start by talking about two related sets of topics that seemed to me important to discuss after reading the hearings of the last several sessions of this body which were sent to me by Mr. Pocock. First there is the problem of delineating and defining what we might mean by an overall science policy anyhow. Second, given the vast collection of programs and policies that fit under that label, is it possible to sort out important differences in kinds of programs and objectives?

My reading of the various reports that have come out under OECD auspices on "Sciency Policy" in a large number of different countries recently has made me sceptical of the utility of defining or thinking of an entity called overall science policy. Let me try to tell you why. It is useful to use the analogue of "overall" economic policy. Is there anything that can be called the overall economic policy of a country? I suspect not, and for the following reasons: First of all, if you look at

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the spectrum of economic policies that a country employs, there are a bewildering variety of different instruments and objectives; some of the objectives are defined at a quite macro level. An example is the acceptable unemployment rate target or an acceptable rate of general price increase, or a target growth rate. So you have a variety of objectives at a quite macro level. You also have a tremendous number of objectives defined at a much more micro level. You have policies regarding agriculture and policies regarding transportation. You have policies aimed at moulding and constraining the structure of industry. You have policies aimed at particular groups, like a wide variety of legislation and programs aimed on the one hand at improving the labour force characteristics in terms of abilities, skills and what-have-you, and programs aimed at special regions like Appalachia.

Similarly you have a tremendous variety of instruments. There are many different tax rates. You have a wide variety of monetary policy instruments of all shapes and forms. You have various programs that are directed and run by governmental agencies like training and retraining programs in the Department of Labour. They blur over into a whole wide range of policies that operate through educational institutions.

The thing we sometimes try to call overall economic policy I find impossible to pin down as an entity, and I suspect it is both unnecessary and unuseful to try to do so. Rather, you have a wide variety of economic policies, many of these quite independent of the others. Relating to this, I think there is a great deal of difficulty in defining where economic objectives and economic instruments end and others begin. Some of the economic policies that I mentioned and many others are concerned with such things as income distribution. Our training and retraining programs are very much concerned with the income distribution objective—the ability of presently under-employed or low-wage people to find jobs. It should be crushingly obvious that over the last couple of years the whole question of economic policy and racial policy, civil rights, in the United States blur into each other.

A number of policies I have talked about, and which any broad assessment of what is economic policy in the United States, certainly would deal with, concern education.

Education increasingly is thought about as a form of investment in human beings which contributes to long-run economic progress and welfare. So, the line between educational policy and economic policy is blurred. How do you delineate and separate the two?

To come to the issue this committee is wrestling with: how do you separate economic policy from science policy? Certainly, the first major beginning in the United States of a conscious science policy—the institution of a patent system early, and the financing of agricultural research—were heavily economically motivated, and can be considered part of economic policy as well as science policy.

So, how do you draw a line between economic policy and civil rights; between economic policy and educational policy, between economic policy and science policy? Because of this blurriness I think it is nonsense to talk about something called a Department of Economics, which nobody has seriously proposed, as a government entity distinct from the Department of State, the Department of Education, and the Department of Agriculture. On the one hand, it would cover all of them, and, on the other hand, it would fit awkwardly into the interstices between them.

In exactly the same sense, I wonder if it is meaningful to think of something called an overall science policy. There is a tremendous variety of objectives and instruments that come under the umbrella. You have objectives relating to defence, to health, to economic growth, to science *per se*, to education. There is a vast variety of instruments: spending, taxes, patent protection, regulatory policy. Many of these objectives are relatively independent of each other. Many of the instruments can be used relatively independently.

What you mean by a science policy, as contrasted with other policies, is very unclear. Much of "science policy" in the United States is defence policy. Science is essentially being used as an instrument of defence policy.

In the hearings and discussions before this committee the blurring of a distinction between educational policy and science policy is striking. A lot of what we mean by science policy is really part and parcel of what we mean by educational policy.

To link back to the earlier discussion, much of what this committee might call science policy could as easily be viewed as economic policy if you had a similar committee set up interested in the question of long-run economic growth.

Because of reasons like this, in the United States the idea of a Department of Science has not really gotten anywhere. When you came down to looking at what it would do, the department would either include a very large part of the activities of much of the federal Government, or would be left awkwardly to operate in the interspaces between agencies concerned with health, with defence and what-not.

Put another way, for most decisions involving science, it is neither necessary nor helpful to have an overall science policy. Consider the question of spending on cancer research. It seems to me the most relevant questions here involve health policy, not overall science policy. Cancer research programs can fruitfully be compared with the need for hospitals and a variety of other public health services other than research programs within the field of health and medicine. It seems to me that you can make much more sensible decisions if the decision is posed this way rather than: should we spend more on cancer research, or should we build a new accelerator?

The minute you pose the question as to whether it will be cancer research versus the new accelerator, you are driven up the tree of analysis to the level of national goals and priorities, and then essentially back down again to these kinds of questions.

I think that this backing and filling reflects the artificiality of a separate entity, called science policy. Defining such a separate entity leads one to compare cancer research with a new accelerator, rather than cancer research with more hospitals. The latter seems much more fruitful for sensible policy making.

Let me now focus on just one component of United States "science policy", that of public research and development spending.

It seems to me that there are at least three different broad kinds of policies and programs that have evolved in the United States. They are very different breeds of cats, in terms of justification.

The lion's share of federal funds for research and development spending in the United States is spent on what can legitimately and quite meaningfully be called public sector research and development. Two excellent examples are defence and public health. What has happened here? A social, political and economic decision has been made that a certain class of activity, such as that of defending the nation on caring for the public health, is the responsibility of government. It was decided that these are subjects that should not essentially be left to private activities. This was a governmental function. Of course, governmental functions, although reasonably well defined, are not clearly defined in terms of profit or loss, dollars and cents, as sometimes you are able to define the objectives of a private business firm. But research and development spending by these two large agencies—the Department of Defence and the national institutes of health—is clearly instrumental towards the achievement of their objectives. That is the basic rationale.

In terms of policy decision at the governmental level regarding the merit of these research and development programs there is a double layer. At the one end a higher level political decision has to be made regarding what kind of defence establishments and what type of capability we want to achieve, and at what cost; what are our objectives in respect to various dimensions of national health, and how much are we willing to pay to achieve various levels of these. Once that is done, the question of R and D support, and what kinds of R and D projects we should undertake, are instrumental decisions in very much the same sense that a business corporation with a reasonably well-defined objective decides on research and development activity versus other kinds of activity. In order to achieve these objectives such as those within the public health field, the question of support of various kinds of research can be posed in terms of what you can accomplish by R and D versus what you can accomplish by having more hospitals, more doctors and what not. You can view research and development as one investment opportunity among many opportunities in order to achieve the objective.

I am obviously moving very quickly over the tremendous range of programs, and the difficulty of forecasting the costs and results of research and development. But, this kind of research and development decision making seems to be reasonably well defined.

This kind of public sector R and D can be distinguished from another broad kind of program. This is public R and D support as a supplement to private research and development efforts in areas where the non-research and development activity is in considerable part left in private hands.

Here in the United States the most striking example and the most traditional one is in agriculture. But there are many new programs similar in spirit. We are now sliding into public undertaking of research on peacetime power reactors, with the intention, however, that once the power reactors are developed they will be deployed essentially within the private sector. There is now the question of the supersonic transport which, like the power reactor, uses public funds on a large scale. The supersonic transport however will be produced and employed privately.

It seems to me that what is going on here requires a quite different kind of justification, a quite different kind of analysis than public sector R and D for public sector activities.

The rationale is some kind of partial breakdown of the private incentive system. I say partial in that you still have not made the sector completely public, as defence. You pretty much leave the aircraft industry private and you tend to leave the agricultural industry private. The analysis seems to turn on the judgment that private activity motivated by seeking profit within the capabilities of the existing private institutions will fail to carry out the kind or the magnitude of research and development that you want done in that particular area. In agriculture in the United States the case was articulated in that way. In the mid-19th century there was the problem that the production units were farms and individual farms do not engage in research and development. At that time we did not have much in the way of large agricultural equipment suppliers. It was very clear that agricultural experimentation and the basic research that leads into it was a high yield investment. There was no one in the private sector to do it and you moved in essentially with the public sector program of agricultural support.

With peacetime reactors it was judged too long-run, too expensive, too risky for the private companies to engage in R & D, and therefore requiring public supplements. In supersonic transport there are exactly the same kinds of arguments. This clearly is a different kind of justification for a public R and D program.

This class of program blurs into a third kind which is public support of science and technology as generalized social overhead. The priorities are pretty much defined by the scientific community.

This third area is differentiated from the second in that the criteria are largely internal to the science community to use Weinburg's distinction. The policy becomes a reality with the establishment of the National Science Foundation in the immediate postwar era, though before that time you had various other agencies partially fulfilling that role, such as the Office of Naval Research to give a prominent example. In the thirties the National Institute had already begun to serve as generalized supporters of science in the biological field, transcending their earlier mission in terms of public health long before the National Science Foundation. Here essentially your prototype in the United States is the National Science Foundation. It provides support of basic research not closely linked either to on the one hand a public sector mission, like type 1, or to an economic objective, like type 2.

In the last years there have evolved some hybrids, like NASA, the Atomic Energy Commission, and most recently the public support of R and D on the supersonic. The justification of the work on the supersonic transport has been posed not only in terms of the desirability of the supersonic transport economically, but also on the ground that if you support work on it you are supporting research on basic technology. Nonetheless, I think that this three-fold classification, the distinction of the kinds of justification for each is a useful one to make.

These are the thoughts and remarks that I believed it might be useful to make after reading the first four sessions of this Committee. Shall we open it up?

The Chairman: I omitted to say at the beginning that Dr. Nelson has a very bad cold, and we are indebted to him for carrying on under the circumstances.

We will follow our usual procedure. I saw Senator Carter writing. I hope he was making notes and not writing a letter home! I suggest that we start with Senator Carter and then go from my right to the left, following our chairman's general procedure, to that this time we will give the distaff side of the Senate an early opportunity to question the witness.

Senator Carter: Dr. Nelson, if I understood correctly what you said, in your opinion there are as many science policies as there are objectives and instruments to achieve them, and the same is true of economic policies. Is that correct?

Dr. Nelson: I do not know that I would really go quite that far. I think there is a tremendous variety of separable objectives and instruments that employ science. For most programs the most relevant comparisons in deciding on policy are much more related to other programs that do not directly involve science, like the cancer hospital bed choice problem. For this reason, to try to separate out something as a separate entity called science policy may be very unhelpful for political decision making.

Senator Carter: As I listened to you, I got the impression that your idea of policy—I am not saying it is not the correct one—is certainly much broader and more comprehensive than what I had in mind when listening to the presentations and questions to this committee.

For example, you talk of economic policy. We have a tariff policy, we have a monetary policy, we have a fiscal policy, and we have the ordinary balance of payments and things like that. These are many things, but they are easily grouped under four or five solid headings which are very much related.

What I had in mind as policy is really some guiding line, some guidelines. We are a small country, of 20 million people. Our finances are limited and yet some scientific achievements are absolutely necessary to keep abreast of the times, to keep our industry up to date, even to keep our educational policies up to date.

What we are looking for is more or less guidelines as to how best we can utilize the moneys available and direct them into the channels which will be the most productive for the national interest.

Take the three sectors which you have defined—the public sector, the research into public research, and the institute.

You mentioned grants. You must have a policy. Otherwise, how are you going to define what support you are going to give to each? Therefore, how do you define your policy in those terms in the United States?

Dr. Nelson: I think the way that you have structured the problem, if I understand you, is that what you mean by science policy is primarily in the third category I was talking about. In this area, the United States started out to support basic scientific research, but now is engaged in support of basic technology in a large number of areas.

I think this is a separable area. I guess that is what I would call a science policy with a small "s". Scientific activities that are not tied to the achievements of some more specified objective, like contributing to defence, contributing to specific health objectives, or something of that sort.

Is that the arena in which you are mostly interested?

I find that when I talk with various people about this, once the talk gets around to this point they start moving into the area of discussing alternatives like "Should we put more research and development into the aircraft industry, or should we be working towards development of independent computer industries?" This immediately forces you to leave the pure science area and the allocation of basic science, and move into the public sector and into the support of industry components of the triumvirate.

What has happened in the United States—and this is what makes the task of the National Science Foundation so awkward—is that even if you limit yourself to basic research, the National Science Foundation is far from being the largest basic research supporter. It is dwarfed by the Atomic Energy Commission, NASA, and the Department of Defence.

Senator Carter: What is the science policy which you mentioned—specifically, for instance, in agriculture? When the federal government of the United States, or a state government, gives supporting grants to agriculture, they must have certain criteria so that they know what they are giving the money for and what they are not going to give money for. Could you give us some enlightenment on that?

Dr. Nelson: There are probably better people than I who could talk about that. As I understand it, the focus from the beginning there was very pragmatic and operational. It was very result-oriented. The concern was to get up agricultural productivity and to get down agricultural costs. The research program involved experimentation on different types of crops and plants, work on seeds and fertilizers and insecticides, and moved backwards into basic research support of the underlying scientific disciplines. For the most part the allocation decisions regarding funds for different kinds of research are decided at a regional level and largely by the research organizations.

Senator Carter: Are there any state barriers to this sort of support? The federal government has to deal with the provincial and state governments. Are there any difficulties there?

Dr. Nelson: Most of this was done on a formal basis. There was a matching funds arrangement up to a certain level.

Senator Carter: One final question. You mentioned three areas and you left out one area. You did not mention universities. Is there any special reason for that? A great deal of research goes on in universities. Does the federal government not have a policy with regard to grants to universities or industry?

Dr. Nelson: It has a number of policies. The basic research funds which channel through the National Science Foundation largely go to the universities. A large share, as you know, is made up of grants to individual researchers from universities coming in with specific grant applications. Some is for larger scale program financing.

Senator Carter: To the universities through the National Institute?

Dr. Nelson: Yes. Universities are the performers of the basic research for which Congress has allocated the funds to the National Science Foundation. This is a different kind of thing from the use of the universities to perform mission-oriented work and that has been employed by the Department of Defense for the last number of years, as well as by NASA and sometimes the Atomic Energy Commission.

The Department of Defense also gives out, at a smaller scale or level, basic research grants, pretty much in the same spirit as the NSF. But a large fraction of the money comes out in the form of specific task-oriented projects that the departments of universities, or sometimes special institutes set up by universities, have agreed to perform. In a way what is happening here is that part of the university structure is operating like an industrial contractor. You are doing more basic work within a specific mission-oriented structure.

As you may know, there is a lot of tension within the American universities as to whether this is in fact compatible with the freedom and autonomy of the university faculty as it has been conceived over the years. The question is important. If it is not, what kind of accommodation, on both sides, needs to be made? These are the sort of issues that relate to the use of universities for the type one and type two activities rather than the type three activities.

A few years ago Charles Kidd wrote a book concerning the universities in the states. Perhaps you know the book to which I am referring, *American Universities and Federal Research*. It dealt essentially with the problems that are now being caused by the use of universities for mission-oriented work by departments of the federal government.

Senator Fergusson: Mr. Chairman, I am sorry that I was not able to be here for the whole of Dr. Nelson's presentation, but I just wanted to say that I find this discussion very interesting.

Senator McGrand: Dr. Nelson, you mentioned the Appalachian system and gave an outline of scientific policy, economic policy and educational policy. How were these applied to the Appalachian situation? I understand they started out with certain difficulties. They were faced with an area that had little or no good agricultural land. It was an area in which the coal industry was rapidly declining. It had a population which was approximately 50 per cent illiterate.

How did they put science policy, education policy and economic policy to work in Appalachia and what results did they get?

Dr. Nelson: One kind of problem, and Appalachia is a good example of it, where the use of research as an instrument for the achievement of social and economic objectives has been much talked about but scarcely employed at all has been in the set of issues relating to income distribution and regional economic difficulties, and things of that sort. The Appalachia case is a very good example.

As I recall the history there, in the early discussions of an Appalachian program there was considerable discussion conducted regarding how to use science and technology as an instrument of regional economic policy to uplift and improve basic economic structure of regions like the Appalachians.

To my knowledge this has got nowhere. Very little was proposed, and what in fact was proposed turned out to be really quite arid. So the science policy component of a regional economic uplift type of policy in the United States, has been for all practical purposes zero.

There is a partial exception. A number of states have been using semi-Appalachian type arguments to support proposals that the federal Government favour private companies proposing research and development work for defence, space and what not, in their regions, in California or the north east.

Senator McGrand: What I mean, Dr. Nelson, is this. What have they accomplished in uplifting the conditions there and providing better income for the people who live in those four states?

Dr. Nelson: Policy regarding Appalachia really boils down to the following not very imaginative package: first, access roads to that region. The second is federal support of public infrastructures, sewers and dams and almost anything that a local government would spend money on. The third facet is support of education.

What has been accomplished? It is really much too early to tell whether it has accomplished anything. These are long-range programs. The roads are just beginning to be built now. The dams and sewers are just beginning to come in. But I do not think anybody, save those who were arguing for the program in the first place, really believes that it is going to reform Appalachia.

Senator McGrand: How many years has the Appalachian program been in operation? Twelve?

Dr. Nelson: It started in 1963 or 64.

Senator McGrand: It was long before that.

Dr. Nelson: Not the big spending, sir.

Senator McGrand: It has been in planning for about 12 years.

Dr. Nelson: Lots of things are in planning for many, many years, sir, but no real program was developed or funds disbursed until recently.

Senator McGrand: At any rate, the unemployed fathers could claim unemployed fathers relief.

Dr. Nelson: Yes.

Senator McGrand: But they had to spend two or three nights a week going to school to learn to read or write. That was part of it.

I spent a week down there running around through those hills, and this is the only thing I could find that they had done.

Dr. Nelson: If you are suggesting, sir, that we have not yet cooked up a particularly imaginative regional economic policy, I could not agree more. But I thought you were trying to get at something else, namely what has been the science policy component to this package, and the answer to that one is also "not much".

Senator Kinnear: Mr. Chairman, I cannot follow the upper bracket in science nearly as well as I can follow the lower brackets. The upper brackets so accelerate themselves that one thing leads to another. I would like to go to the other end and ask you a question concerning your condensed version of your book. When I got toward the last part I became really concerned about the small amount of resources allocated to research and development in sectors that Galbraith pointed to, the non-defence public sector of housing, education, pollution and so on. That is the area I am really interested in, and I wonder if you feel that there should not be more effort put into that?

After all it is the people who are concerned. We don't spend as much as you do on defence. I imagine your percentage on defence in the United States is rather high. Is it 80 or 85 per cent of your R and D?

Dr. Nelson: Well, there you have trouble defining boundaries. I think direct Department of Defence expenditure is 60-65 per cent.

Senator Kinnear: We have the same need in Canada—an urgent need for housing and a great need for something to be done to look after the pollution of our waterways and urban services. I would like to hear your theory as to what can be done in that line.

Dr. Nelson: I think in the United States the response to this so far has been quite unimaginative. Let me give you two areas where I think we are hung up on science policy. One of them is research and development on low-cost housing. There is no question but that public programs in the field of low-cost housing are deterred by what Congress perceives as the extremely high cost per unit put up. A number of technologists involved in this activity tell you that we can build low-cost housing much more cheaply than we are doing at the present time. In the United States an experimental program was tried in the immediate post-World War II period. The program subsequently was scotched by the housing industry which was concerned about a possible threat to their own well-being and to their ability to perceive their future. That program lasted, I think, one or two years and then was revoked by Congress. In 1962-63 a similar program was proposed and rejected. Whether the new Housing and Urban Development Department is going to be able to crack new ground, I do not know.

Another good example is R and D on the atmospheric pollution problems associated with fumes from internal combustion engines. I understand you can design automobile engines using different fuel sources that will not generate this problem, but how are you going to get public support of research on that with the oil industry standing by?

Senator Kinnear: I would like to say that it seems to me that they are short-sighted when they don't go after that and get the air cleared from fumes because cancer is such a major tragedy and air pollution is probably a contributing factor and also of course pollution of the waterways is an international matter. I hope we are going to do something about that very shortly.

The Chairman: I wonder if I might clarify this. Are you saying that the oil industry is actually resisting the development of research and development to cut down pollution from combustion engines?

Dr. Nelson: I do not want to say that, but what do you think the chances would be of getting public R and D funds to be spent on automobile engines that would not use petroleum or petroleum products?

The Chairman: I won't answer that.

Senator Kinnear: But do you feel that they cannot stop the fumes of the oil industry without using another fuel?

Dr. Nelson: I don't know. I am not technically enough skilled in this field, but I know a number of chemical engineers who are taking the point of view that if you put enough funds into a wide variety of engines other than the internal combustion engine that before five or ten years are gone by you will come up with something worth while.

Senator Carter: Is that inhibiting the research towards cars driven by batteries?

Dr. Nelson: I have not looked into this, but somebody might be interested in looking at it. The federal Government is now giving limited funds for research on various ways to deal with the automobile smog generation problem. I suspect that if you look at the projects to which funds are being allocated you will find that engines that do not use petroleum products form a small part of it.

Senator Kinnear: You said in one spot that inventions take an average of 12 years for acceptance, so it is quite a while before you get anything very new.

Senator Lang: Dr. Nelson, I take it from your remarks that the United States has never really evolved a science policy, as such, but has rather adapted to the various pressures as they arose and adapted to use science to meet the exigencies.

Do you think your country ever could have or would develop a science policy, as such, that philosophically is something apart from Government policy? Is there such an animal as science policy divorced from Government policy, or are we only talking about Government policy towards science?

Dr. Nelson: I do not know whether your question is directed towards the generic issue of whether there is something called a science policy *per se* that is a useful way of looking at things, or whether it is a question about the ways policy is looked at in the United States with its own peculiar attributes.

My earlier comments were that I am not at all sure that it is particularly fruitful for anybody to think of something specifically called a science policy, which incorporates within its delineation the wide variety of activities that employ research and development that go on in any kind of country—the United States, Canada, the United Kingdom, or the Soviet Union. It is too diversified a thing. To come back to the earlier example, when you are proposing research in the field of health, it seems to me much more fruitly to compare it with programs to supplement the supply of doctors, to improve and expand hospital facilities. These are the relevant and most useful comparisons and packages to think about, rather than contrasting research in the field of health with research in the field of space.

The Chairman: Is this not this area of distinction between science in policy and policy for science?

Dr. Nelson: I do not know. Do you want to try that back and forth and see where we go?

The Chairman: I would say this, that for my own part in our previous sessions I thought I was beginning to understand our terms of reference and I was really beginning to think I knew what we meant by "science policy." What you have said today has shaken me up a little, and I have been wondering what our terms of reference are. Are we being asked to come up with a policy for science as it operates within the Canadian framework; or are we really to say what influence should science, in the broad sense, have on political policy—or are they the same?

Senator Leonard: Or vice versa.

The Chairman: Yes, or vice versa.

Dr. Nelson: I think you might be able to separate some of the issues this way. There is going to be, and should be, within any modern state, a considerable number of activities, research endeavours, conducted by scientists and technologists that are not going to be keyed to any specific applied program or any well-defined national objective, defined in terms of raising per capita incomes, and improving defence capabilities, improving the climate of health, and what-have-you.

Yet basic scientific and engineering research, when it is fruitful, yields payoffs that seem to crop up in just about every walk of life. Thus, some kind of policy of providing support for this class of non-mission linked activities has to evolve in a country. Such a package of policies can be viewed as a policy towards science, a science policy; and that is a very important package.

I suspect, however, that in just about all countries the percentage of public funds spent on research of this kind is going to be quite small relative to the total public or national research and development spending.

Furthermore, within the more mission-oriented activities, it seems to me that the most useful way to look at the problem is in terms of research and development, in complement with, and sometimes in competition with, other forms of investment, to achieve mission-oriented objectives. If you are really thinking about how to improve mass transit systems in large metropolitan areas, and have made a judgment that this is an activity you must expend considerable amounts of funds on over the next 10, 15, 20, 50 years, then you can ask the question, how much and what kind of a research and development program you want as part of that package.

Here you have to ask questions like: how good are the technologies that we have in hand right now for improving the long-run objectives of a mass transit policy? What are the funds required to bring into play these already existing technologies, to build the hardware for them? What are some of the weak points in this complex of technologies that are involved in interurban transport? How can we increase speed, reduce weight, occupy less space, and have a much more efficient, more desirable, and less costly system? Are these the kinds of problems to which research and development might fruitfully be allocated? How much should you spend on research and development on new systems—systems of the future—and how much should you spend on bringing into operation the systems you can have at the present time?

This, it seems to me, is the most fruitful way of thinking about research and development and the creation of new technologies in the field of transportation. You begin to develop a science policy in respect to transportation. To do this one must look at the broad transportation package and uses of funds. It is very useful, it seems to me, to worry about whether you should spend some more money on research into new transportation systems, vis-a-vis putting into place systems that you have at the present time it is much less useful to pose the alternative as to whether you should spend some more money on public health research.

Senator Lang: Dr. Nelson, would you agree that pure non-mission oriented research and scientific policy are basically antithetical?

Dr. Nelson: I think they are different cats, but they are complementary. You want both mission-oriented applied research and development, and some basic research aimed at specific problems, and non-problem oriented basic research at the same time. Companies like Bell Telephone support a considerable amount of quite freewheeling basic research without any particular or exact notion of where or how that is going to pay off. Similarly, a country should have some kind of a mix or a blend between mission-oriented work, which we have now learned is apt to take a very large share of the funds available, and basic work which just is not tied to that at all. You want some of both.

There has been a tendency over the last five or six years to do two things. One has been to recognize, and I think rightly, that just as there is a good case for supporting basic research in the sciences so there is a good case for supporting quite a bit of basic technical work on new materials, new processes, new power sources, even where it is very difficult to see where the payoff is.

So, in a sense, the national science foundation is now implicitly being broadened to embrace work in basic technology. We have not faced that in the United States. In a sense, what we have done is to artifically, and I think rather perniciously, box the support of technology into rather peculiar subareas. You made a decision, that you wanted to put a tremendous amount of work into nuclear technology. The decision was in terms of a particular area of technology and there was not much of a worry that there may have been lots of other technological areas that you could push as well. So, you set up a large apparatus to finance work in that technology, the requirement being that it be atomic or nuclear. Later we decided on a large space program. A large part of the justification, as in atomic energy, was that in doing that you were supporting a lot of the work in basic technology.

So you are, but you are doing it in such a way that biases your effort for no particularly good reason. So, your basic work in technology is now being supported through defence, space and atomic energy. What is happening behind the scenes is that you are groping towards a national technology foundation, or an expansion of the national science foundation, to something like a national science and technology foundation.

But you are caught in the peculiar bind where you have an entity called NASA which has just about achieved the mission it set out to achieve, that of getting to the moon. You conceive of using this agency for a lot of other purposes, like supporting technology. You need a national technology program if you are to avoid the silly question, "What is a new mission for NASA in order to keep this particular entity going."

The Chairman: Who is going to get to the moon first, and when?

Dr. Nelson: I hear that you have a secret program, and you are going to beat us all.

Senator Yuzyk: I have been trying to follow the discussion here. We are going to try to resolve some very difficult questions, and having a person such as yourself, Dr. Nelson, here, I would like some advice from you on the basis of the experience of the United States.

Dr. Nelson: I will try to help.

Senator Yuzyk: I look upon our basic problem of being that of how to make the best use of science in the broad field for the good of the nation and of humanity.

Dr. Nelson: Yes.

Senator Yuzyk: Science is involved in every aspect of human life. Governments have to give direction—at least, many of the top scientists have told us that governments have to decide on priorities, and have to decide on what should be supported by subsidy—what is going to be a government project, on what is going to be in private sector—and what is going to be in the field of the universities and educational institutions.

Now, I am concerned when I am given to understand that science can produce a better method of, say, transportation, but that vested interests will try to stop or block the use of science in that respect. Consequently, I try to resolve in my own mind the question of whether at some place, for the good of the people, there has to be a central agency which will take into account not only the fact that we have nuclear power now—and we are making the best use of nuclear power—but also the fact that the potentialities of science are limitless, and that it may be possible that some other source of energy, like solar energy, will be cheaper, more beneficial, and will not have the by-products of pollution that other sources have.

In such cases, of course, governments would have to allocate funds to promote such fields of science, whether they are concerned with industry, health, or any other aspect. Would you recommend such an overall science agency, say for Canada, where it might be a little more feasible in view of the fact that our development is along certain lines and certain vested interests are not that powerful? Would you go that far? Today in what you have said you have really over-fragmentized science with economics, but still we have to integrate this through some source.

Dr. Nelson: Certain functions of a central coordinating advisory body would be extremely useful. Given, as you say, the public purse, its availability or lack of availability will be both a constraint and, where it is relaxed, an opportunity in terms of where scientific and technical resources go. You have to have some type of mechanism whereby two kinds of consideration come together. There must be some mechanism whereby members of the scientific community can communicate to members of the Government that a particular field or a particular type of activity now looks very promising, and if funds are put into it the payoff may be very considerable.

This is the kind of mechanism whereby, for instance, research on oceanography in the United States has been expanded tremendously over the last five or six years. This was effected in good part through the President's Science Advisory Committee machinery, reporting that this field looked very, very good indeed and the payoff would be quite considerable if we put funds into it. The same kind of thing happened with regard to molecular biology and considerable funds are now channelled into that. You have this web of advisory committees and mechanisms tapped into the scientific community. You need some type of organizational structure to be attuned to and therefore shift allocations of funds to areas which looked much more promising than they did before.

I think you also need machinery to thrash out what, if any, kind of role the scientific community and research spending in various shapes and forms can play in meeting new national objectives and goals. As you begin in the United States to evolve this amorphous set of objectives regarding the reconstruction of cities you have to have some mechanism for running a continuing dialogue with the relevant members of the scientific community to find out what implications, if any, that new set of objectives might have to relocating research funds and putting efforts into programs that will contribute to that end.

You need machinery in the government to identify opportunities that look much better than they did before, and to get feed-back from the scientific community regarding what might be the research and development scientific policy implications of a shift or a change in higher national objectives. I suspect the machinery here really is a layered one. You will certainly need something at the high level. You have a web of institutions in the United States to do this, such as PSAC and to a lesser degree the National Science Foundation. You also have that type of apparatus going on within each governmental department—in defence, in health, in agriculture. You need both these kinds of mechanism, whether or not you form a department.

Senator Yuzyk: Would you say it would be feasible to set up a mechanism of that kind which would serve even the interest of a particular department, but above all try to give direction to perhaps new goals which sometimes are not even foreseen at that particular time?

Dr. Nelson: Yes.

Senator Leonard: My question really follows along the lines taken by Senator Yuzyk. I should like to bring the general down to the particular. My question deals with an article in the London *Economist* of February 17, 1968, which you may or may not have read. It deals specifically with this question in the United States. I have in mind the budget of $17.8 billion for R and D, as it is called. This article, which was written by a correspondent of the *Economist*, a paper of some knowledge and influence, is on the whole rather critical of the priorities in spending the $17.8 billion.

Without reading the whole article, but just to give you some of the items, may I say that one of the items that he mentions is "the lack of money for what Washington calls 'new starts'—and in which there is a tendency for the old program to absorb the money and, particularly when there is not additional money, new starts cannot go ahead.

It referred also to expenditures by the National Institutes of Health, the fact that an investigation by Congress on the NIH, showed it had "dispensed its millions with a carelessness inappropriate to scientists."

It mentions expenditures to universities, and the descriptive phrase that is used is that "this random pump-priming can be afforded no longer".

Then it poses this straight question: "Why not a central agency to preside over the handing out of money for scientific research?"

You spoke of the National Science Foundation, and the *"Economist"* writer says, "Many people think that the timid National Science Foundation should be given the power and the money to do the job."

The fact that it calls it "timid," suggests I think, that it has not the courage at any rate to do it. The writer says: "Others will think that the President's Science Adviser and the Office of Science and Technology are already doing it."

Then it refers to the fact that Dr. Wiesner, who is the President's Science Adviser, "makes no secret of the fact that he disliked the race to the moon, but Project Apollo, on which over $20 billion has been spent, was begun anyway." He concludes that "The big science money has gone to the causes that Congressmen like best—defence, atomic energy, good health, and space."

Therefore, he says, "it might be a good time to set up a really strong Department of Science and Technology."

I realize that this is just an opinion, and an outside opinion, but my question to you is: Do you think that the machinery of the United States Government, in dealing with this matter of priorities of expenditure—which machinery I understand is practically all on an advisory basis—do you think that is sufficient; or should there be more power, either in the hands of the existing advisory committee or in the hands of some new organization of government, for the purpose only of determining the priorities of, say, the expenditures of $17.8 billion—or whatever additional amount it may grow to?

Dr. Nelson: May I circle around that question, as I think implicitly here there are a number of points to it? First I am not at all sure that a big round number like $17.8 billion on activities that are called under one label "research and development" is a particularly interesting or meaningful number for any purpose. This has been one of the points I have been trying to get at, perhaps awkwardly, through the session.

That number covers all kinds of different activities which are rather arbitrarily called "research and development". Slight changes in the definition lead to very large changes, it turns out, in the number that you write down for expenditure on research and development.

Furthermore, it is not even so that it is a meaningful number in terms of defining a constraint on the total magnitude of this heterogeneous collection of activities. The resources involved in certain kinds of these programs that come under the label are different from the resources that are utilized in others. It is not true that if you cut back on spending on medical research you free up resources that have very high priority uses in space, or vice versa. The people involved and their training are different. Furthermore, a very large share of the expenditure, for example, of what we call research and development in space, does not really involve expenditures on scientists and engineers at all. It is the building of hardware, it is essentially the utilization of steel, glass, copper and so on.

I do not think you can say: "The United States has $17.8 billion of research and development capabilities—let us figure out how we can re-allocate that amongst lots of different activities."

Further, in many cases the resources within it are not so very different than resources not presently employed in it. A large percentage of the engineering population in the United States is not now engaged in research and development at all. They might well be brought into R and D activity under various programs.

A second point is this, and it comes back again to an ealier comment. I do not think it would be a good idea to centralize mission-oriented R and D decision making to strip these decisions away from the departments. I do not think there should be a central body that decides on overall research and development allocations. The reason is very simple. If you look at the bulk of research spending and development spending in a country like the United States, the lion's share of it is mission-oriented. It is oriented to missions of a particular department, and that department, for better or for worse, has been charted by legislation to perform certain kinds of missions and objectives.

Given that political wisdon or unwisdom, given a mandate to the Department of Health, Education and Welfare to spend funds as best it can to improve the health of the nation, given that you have told them to do as best they can, they are naturally going to look toward research activities as important components of a sensible policy to achieve their politically delegated mandate.

The mandate has been delegated to them. They are the agencies responsible for it. Their research activities, it seems to me, should be weighed and compared by them in the context of other activities that they could be engaging in to achieve whatever objectives the policy makers in their wisdom or lack of wisdom have designated they should have. To delegate the research and development support component of the Department of Health, Education and Welfare to the National Science Foundation is essentially to say that you do not believe in a Department of Health, Education and Welfare as an agency that is concerned with health across the board.

If you believe that health is a definable objective and you want to set up an organization to deal with that type of thing in the form of a governmental department, it has got to be able to have research and development spending, contract letting, grant giving authority as part of its mandate.

The argument as to whether they are spending too much or too little on defence research and development is in large part embedded in the larger context not of science policy but of defence policy of the United States. Does or does not the Department of Defence and the national security establishment of the United States have a reasonable and realistic assessment of the nature of the threats that the United States and its allies face? You can argue about that but that is a proper level for a dialogue with respect to defence research and development spending. There is the derivative question. Given its mandate is the Department of Defence being sensible? Given the objectives and budgetary constraints in spending, is the Department of Defence sponsoring the correct menu of projects in defence research and development.

But this is a question of how sensible and sophisticated the Department of Defence is regarding the fulfilling of its mandate. But at a higher level the basic question is: do we have the right kind of defence policy and the right defence outlook?

Much of the argument about science policy really amounts to an argument about high-level political value decisions. You cannot say that you are going to have a massive space program, which is an arguable issue, and at the same time say that NASA should not have control over the research and development budget, which is its primary instrument for the achievement of that kind of objective.

I guess it all boils down to the point of view that: "No, I do not think that you can have a national science policy. I do not think that you can have a single organization called the Department of Science and Technology, that controls the bulk of government research and development spending without at the same time essentially moving to an entirely different set of attitudes regarding what permissions, responsibilities and instruments available to your mission-oriented governmental departments, defence, health, space, education and what not, would be."

What you essentially would be doing is stripping from them a tool that in a number of these departments is one of the most important instruments toward the achievement of these objectives.

Where does this leave a national department, if you want to call it that, of science or science and technology? What you end up with is something like the National Science Foundation, plus advisory and co-ordinating machinery.

The National Science Foundation is concerned with financing research expenditures that look like they are in the national interest but which are not financed out of the mission-oriented government departments.

So it sort of acts as—and this is the language that is now being used increasingly in talking about the National Science Foundation—it sort of acts as a balance wheel.

A number of people in talking about the National Science Foundation have observed that increasing amounts of funds are going into defence, going into space, going into atomic energy. The National Science Foundation in the balance wheel concept has the function of making sure that the short and medium run objectives of mission-oriented government departments which are financing the bulk of research and development do not essentially leave you in the position where you have stripped various fields of science or sources of support where some time in the future you might very well want to have strong efforts in this particular field.

So, in a sense, the National Science Foundation in its balance wheel function is a defender and provider of funds on the criterion of scientific merit or pregnancy, in Weinberg's sense. It is the defender of the universities, a defender of the science faculties of the universities. It defends them from too much pressure and too much pulling and hauling from the mission-oriented government departments.

In the United States the advisory and co-ordinating function is separated from the National Science Foundation. These activities certainly are functions also for a Department of Science and Technology.

Senator Carter: Could I have a supplementary on this?

The Chairman: Certainly. But I would draw the attention of honourable senators to the time. We have kept Dr. Nelson here a long time, but go ahead.

Dr. Nelson: I am delighted to stay as long as anybody else wants to stay.

Senator Carter: While I was listening to Dr. Nelson's answer to Senator Leonard's question I was thinking of Russia and China. These countries have made tremendous progress in scientific achievement in a comparatively short period of time and I was wondering what was your opinion on the way they have proceeded—was it on this balanced wheel concept or through a strong central agency?

Dr. Nelson: The latter. I don't know either of these cases as well as I might.

Senator Carter: Well, could I put it this way: Do you think they could have made this progress so fast and could they have done so much without the direction of a strong central agency?

Dr. Nelson: Are you talking now of the Chinese or of the Soviet Union? I suspect in the case of the Soviet Union the answer is yes. But they stressed very strongly defence, space and atomic energy and that is where they put their resources. What the Soviet Union did, I think, and what was basic to all their efforts was to make a bet a long time ago that the modern industrial state had to be tremendously rich in science and engineering. Consequently they made the effort way back to pour out large numbers of scientists and engineers. But they have been putting their efforts pretty much into the same areas as the United States has done with a lot of the same consequences. In particular you will probably hear more laments, or so I have gathered from some of my friends who have been in the Soviet Union, about the way in which they have been depriving certain other areas of the technical talent. What they have done was to put a tremendous amount of effort into defence and space.

Now with regard to the Chinese, I gather this is a very mixed bag of tricks. Tremendous importance was attached to scientific education, and this, as in the case of the Soviet Union, is something you cannot do unless you have a powerful centralized thrust behind you. The impressive performance of the Chinese is again in a few selected areas, and whether or not they would be better off if in fact they had allocated their efforts more evenly over a number of other areas or not is very unclear. I gather very little has been done in agricultural research.

Senator Carter: I want to clarify one point to which you referred earlier. You referred several times to the supersonic transport and public support for the supersonic transport. Were you referring to the aircraft being built by the Douglas Aircraft Corporation like the Concorde in France or did you have something else in mind?

Dr. Nelson: I am talking about the American supersonic. Our decision, it seems to me, was largely the result of the Anglo-French decision to go ahead with the Concorde. And they seemed to do that because they thought we were going to do something like it. The record of people who have been biased against large scientific and technological efforts and who talk about how fruitless they are going to be has, of course, been notoriously bad. I am worried about this but it seems to me a real squandering of our social resources. This is purely a reaction on the part of two groups who considered themselves in some sense in very strong competition about something. But it is justified on very little grounds other than that somebody else was doing it, and if we didn't do it we could be in serious trouble.

The Chairman: Honourable senators, I am sure you will want me to express our thanks to Dr. Nelson and to tell him that we do not agree with his casual use of the word "awkward" in connection with his presentation to us. It has been anything but awkward. On the other hand, I would not like to say that I personally have absorbed or digested the tremendous wealth of information he has brought to us.

I know that when your testimony is printed, Dr. Nelson, you are going to have some constant readers among the members of this committee and indeed in other places as well because of the wide interest that is being generated by our proceedings.

I do want to thank you and to tell you that whereas you may have raised some doubts in our minds about our competence to absorb, as laymen, this kind of information, you have certainly made it clear to us that the job we have to do is a very important one and that it is going to take us many, many sessions before we are ready to perform our major function, and that is to make a report.

You have been very helpful to us. We thank you for coming all this long way to spend this short time with us.

Dr. Nelson: Thank you. It has been an honour and a privilege. I hope I have not wasted your time.

The Chairman: Far from it.

The meeting adjourned.

THE SENATE

SPECIAL COMMITTEE ON SCIENCE POLICY

EVIDENCE

Ottawa, Thursday, April 25, 1968

A convocation of members of the Senate met this day at 3 p.m. to consider science policy.

Senator Maurice Lamontagne (Chairman) in the Chair.

The Chairman: I want first to tell the members of the committee that my absence yesterday was not caused by any recent event which happened in Ottawa. It was caused by a long-standing engagement to speak in Quebec City about syndicalism and the problem of poverty.

Our witness today is Dr. Alexander King. I am not going to give you a detailed description of his biography; I am going to say only that Dr. King has been a pre-eminent international public servant since 1951, and is now the Director for Scientific Affairs at OECD. Dr. King in coming to Ottawa today has a kind of dual role; he is of course a wise man in the field of science policy but he is also at the present time more or less like an outsider looking in. His organization is now preparing a special report on Canada's scientific effort. We know, and we have heard this from previous guests of the committee, that these reports on member countries are prepared very carefully and have proved to be most useful to these individual countries.

I hope that Dr. King will have the opportunity, in the course of the afternoon, to describe the approach that is being used by his organization in making these studies, because I believe that this might prove to be most useful for the conduct of our own inquiry in future. We might try to imitate you.

So, again, I want to welcome you on behalf of the members of the committee. You have been so kind to come to Ottawa at this stage, in these uncertain times for Canada, but this is a great opportunity we have to receive you and to obtain the benefit of your advice.

Senator Connolly (Ottawa West): Mr. Chairman, before Dr. King begins, I wonder if I might trespass for just a moment on the time of the committee?

The Chairman: I want to say, first of all, that we have, as you know, a new Senate backbencher amongst us today, Senator John Connolly, the former Leader of the Government in the Senate, and he has decided to join us in the group of backbenchers.

Senator Connolly (Ottawa West): I am in good company, I can tell you, Mr. Chairman, and I am very happy indeed about it.

I want to say that I had the privilege about a month and a half ago of attending on behalf of the Minister of Industry a meeting of the science ministers from all the OECD countries in Paris. I have already paid tribute to the wonderful backing I had, as spokesman for the Canadian delegation, from the officials of the Science Secretariat, the Department of Industry, the Defence Research Board, and other groups, some of whom are here this afternoon. I do want to say, on behalf of the Canadians who were there, how grateful we all were, and how grateful the Government was, for the kind of reception we received at the hands of Dr. Stoltenberg, the Chairman, who was from West Germany, at the hands of the Secretary General, Mr. Kristensen, who I think is one of the great men of the world, and at the hands of the distinguished guest and witness you have here this afternoon. I am sure those who were in attendance with me—and I speak particularly now of and I look at Mr. John Orr—would all endorse everything I say.

In my former capacity of Leader of the Government in the Senate I was, as you know, most interested in the establishment of this committee, and I have followed its proceedings with great interest. I think this is one of the great landmarks, or milestones, perhaps I should say, in the life of the Canadian Senate; and to have such distinguished personages appear as you have here this afternoon is evidence of the fact, which should not only be recognized in Canada but is, in fact, recognized all over the world. So, I should like to welcome Dr. King personally as well.

Hon. Senators: Hear, hear.

Dr. Alexander King, Director for Scientific Affairs, Organization for Economic Co-operation and Development: Mr. Chairman, Senator Connolly, gentlemen, I am very touched by what you have said. Personally, I do not at all feel like an outsider looking in; it may be presumptuous, but I always feel rather at home in Ottawa. I was calculating with my old friend Jack Mackenzie at lunch time that this is perhaps my fortieth visit to Ottawa; I have been in and out for the last 25 years. I think I have known all the Presidents of the National Research Council, from Dr. Tory onward, in a personal capacity, and I have great feelings of affection and respect for your country, with its enormous potentialities. So I come here essentially as a friend.

If I may proceed with my task now; I would like to say at the outset that this question of science policy is basically an extremely complicated one, much more so than it seems at first sight. Its history is rather short. I remember only seven or eight years ago mentioning the concept to the Council of OECD, but it fell on deaf ears because science policy seemed to them to be not premature but rather irrelevant, because the relationship between science and policy was not at all understood.

Science, in many European countries particularly, was regarded essentially as a cultural matter; its relationship to society through cultural activities existed, but its function in relation to wider and immediate problems of social and economic importance was over the horizon.

OECD—the organization which I am serving at the moment—has had a pioneering role in science policy, and I would just like to mention for the record that the first work done in OECD on this subject was by a Canadian. The first survey made by OECD of science policy in Europe was made by Mr. Dana Wilgress, whom we chose to do that work just because he was not a scientist. This, in a sense, is the key to our approach, because our group, while intensely concerned with the development of science in the national interest broadly, has been very anxious not to be a lobby for science or a vested interest, so, consequently, we felt at the beginning of this long exercise that we should involve someone, an economist, preferably, with an understanding of the needs in science and how it works, but without his having a personal stake in it. This proved to be an extraordinarily good selection, and the report by Mr. Wilgress led, in fact, to the starting up of science policy activities in OECD.

I have made one mistake there, because OECD did not exist at that time; this was OEEC, the Marshall Plan Organization, which was the precursor of OECD.

As soon as OECD was founded, Mr. Kristensen, the Secretary General, in his first few months of work, set up a high-level study group on science policy. One eminent Canadian sat on that group, namely the late Dr. Steacie, the then President of the National Research Council; unfortunately he died before this work was completed. I can assure you, from conversations with him, that he was personally extremely involved in this work in his mind, and that, had he lived, I am sure the effect in Canada would have been quite direct.

This group of natural scientists and economists, first of all made the very clear distinction, which I think should be in our minds today, between the two faces of science policy, namely, policies for the management and effective development of science and, secondly, science for policy—the influence of science on the various facets of national policy on which it has a bearing.

These two facets, or these two sides of the coin, are very different in their manifestations, and need very different treatment. It is important to bear in mind in a discussion of this subject that these two separate approaches or separate interpretations of the term "science policy" exist, and must co-exist if science is to be employed for the national well-being.

Following the report of this group which was entitled "Science and the Policy of Governments," in 1962, a series of ministerial meetings have taken place, the third of which was just mentioned by Senator Connolly (Ottawa West).

The first of these meetings took place in 1963, and it is interesting to see how they have evolved. At the meeting in 1963 less than a third of the ministers present were really ministers with a general responsibility for science. More than half of them were, in fact, national ministers of education who had, of course, through the university preoccupations, an important function in basic research. Only a few countries had, in fact, ministers looking at the whole approach and scope of science, and its application. So, in a sense, the first meeting, which was attended by Mr. Drury for Canada, was educational.

But, by the time the second meeting had taken place in 1966, two and a half years later, more than half the ministers were science ministers. So, in that period the impact of these initial discussions had, in fact, created new ministers in quite a number of countries, or a change in the functions of ministers in such a way that the science responsibility was clearly delineated.

At the third meeting which took place just a few weeks ago, the ministers attending were, in fact, a mixture of ministers concerned directly with science and with the economy. For example, the Swedish delegation consisted of the Minister of Education who was deputizing for the Prime Minister, and also the Minister for Economic Affairs. The German delegation consisted of the Chairman, Dr. Stoltenberg, the Minister of Science, together with the State Secretary for Economic Affairs. The Netherlands delegation consisted of the Minister of Education and Science, and the Minister for Economic Affairs.

This, again, in the evolution of these meetings, indicates the way in which other ministers, and particularly those concerned with economy and industry, have been strongly involved in this movement.

Senator Connolly (Ottawa West): And the Belgians sent their Prime Minister.

Dr. King: Yes. At all three meetings the Belgians have had their Prime Minister present because he is the Minister for Science as well. I shall point out later the extent to which ministerial responsibility for science has been accepted and delegated.

The emphasis has changed considerably throughout this short period of years from a concentration on the need for policies for science, its development and its management, to the impact of science on policy and, I go further and say, to an acceptance of the general concept that science can be a catalyst in society—a catalyst and an innovator—for development, and its influence can be felt on many facets of national policy. But, it can only be felt quickly, profoundly, and wisely if the relationships are established between those who can apply its findings and those responsible for deploying the overall scientific effort and thus carrying the policy out.

This emphasis is likely to continue for the next number of years, and this leads us to a concept of science policy that is perhaps similar to what was developed yesterday by your last guest speaker, Dr. Nelson. We more and more have come to think of the situation as being one in which science is a sub-system in the total national system, but as a sub-system it overlaps a number of other sub-systems. Thus, science has its influence on national health; it is very clear in defence. Its influence is great, or should be great, on the economy through industry and agriculture, and in many other fields. So, all of these sectors interact on the science sector, and on the science effort.

Clearly, in any country, the amount of scientific effort devoted to a mission-oriented department of government, or a mission-oriented agency, will depend on the importance given to it by those responsible for the department—let us say, health or forestry, or whatever it may be—and this will also depend upon a recognition of the possibilities of science in that area, on the availability of appropriately trained scientists, and on the general state of scientific achievement in the country concerned.

So, decisions as to the allocation of scientific resources are, therefore, very difficult to take centrally. A number of countries, particularly Belgium and France, have attempted this, and have, in fact, centrally concentrated scientific budgets. All the scientific resources of the country are accounted for together, and are then deployed as between all the various competing elements.

But, a number of other countries, including the United States and Britain, feel that this is wrong, and that the users of science or those responsible for the various sub-systems of national policy have to make, system by system, the decisions which will determine not the proportion of the scientific resources of the country to be used, but how much scientific effort is required in their sectors of health, agriculture, or whatever it may be, in terms of needs and resources, etc. The total availability of sources is a complicated balance of the needs of the users, and the availability of science in terms of numbers of people, total resources, balance of skills, etc., in the centre. So here this is inherently a very complex systems picture.

I put it to you, sir, that any country which regards the allocation of scientific resources in a too simplified sense is unlikely, in fact, to secure the major utilization of its scientific resources towards the attainment of national goals.

This, I think, is a gradually accumulating experience. I think it explains the trend in most countries away from the idea of having central ministeries of science, and towards having more flexible arrangements for policy, and very close linkages between the scientific policy activities on the one hand, and the policies for the different aspects of government interest on the other.

The position of technology, I think, is of particular importance in all of this. Technology, as the application of science, of course, has its greatest or most obvious influence in industry, but, of course, its influence is more and more seen in subjects such as transportation, agriculture, mining et cetera. One of the trends which we are looking at today, especially in the research intensive industries, is the trend for the demarcation line between science and technology to disappear. In many of the most advanced industrial sectors a man may be acting as an engineer one day, and as a physicist the next, and the feedback from industrial application gives rise to new discovery. New discovery feeds new application, and a very interesting symbiotic relationship is established. This applies essentially to the more advanced activities.

The second major trend in national science policy is, I think, that countries are, without necessarily expressing it, being concerned more and more not simply with policies for science but policies for science and technology. This is very important to take into consideration with regard to your own work here.

The statistics are nearly all expressed as statistics for research and development. It is extremely difficult to isolate the figures for science as such from those for its application, and I think this tendency towards technology and science policies being regarded together is right and is in keeping with the kind of systems picture of the subject which I have already mentioned.

There is, however, another aspect of this system which is extremely important. I mentioned that science could be regarded as a sub-system in the national system of policies impinging on many other systems and resource of science being used in relation to the attainment of national goals in these other systems. Within the scientific resources, however, there is a very big part of the total effort which is used for maintaining and sustaining the scientific machine and its vitality. This is basic research, often regarded as sacrosanct, yet its cultivation and its utilization of resources for itself is a part, and very important part, of the question of policies for science.

The importance of basic research for the maintenance of science cannot be overestimated. The extent to which national resources are given to it *can* be overestimated. This sector is important for two reasons. First of all there is an increasing appreciation that unless a country does sufficient fundamental research to attain a certain level of scientific awareness it is unlikely to be successfull in applying the results of knowledge, whether they be domestic or foreign, sufficiently quickly and sufficiently well, so that the basic research, self-sustaining sector of the total scientific resources in this sub-system is important in relation to the vitality of the system as a whole. Its second importance is that it is this independent part of the scientific effort which produces, through the educational and training systems, the people who will put science into effect as managers of technical processes, as innovators, as general managers, scientists and technicians who are concerned with the application of science and with the operation of science based industries and the rest. Here, therefore, we have another element of the complexity of whole system.

With this complexity and breadth of interest, an immediate problem comes up in most governments, which is how to divide responsibility for science. Within science and technology there is a whole spectrum of activities which extend on the one hand from the educational system, through higher education, basic research, applied research, development and technology in general, to production in industry. Clearly in the distribution of competence within governments this is too big a package for any one minister or any one ministry, so that up till now countries have had to concentrate in deciding where to cut it. The British, for example, for many years made the break between university research and the rest of science which came under the Department of Scientific and Industrial Research and other research councils. A year or two ago, they reorganized to cut it between science and technology, and many people feel there is a kind of schizophrenia as a result of that. All countries face this problem and as a consequence the debate on the organization of science is going on everywhere. Certainly it continues within OECD, and I understand also in the countries of the communist world, which are facing practically the same problems under different names.

Various national approaches have been tried to solve this. In a number of countries the trend is towards the creation of central scientific policy groups or scientific and technical policy groups. In three European countries the minister for science is formally the prime minister. This is true in Belgium, Norway and Sweden. In Japan responsibility for science is again with the prime minister, who exerts it through a minister of state, a vice prime minister in his own office.

Going back in history it is very interesting to remember that in Israel Mr. Ben Gurion, and in India Mr. Nehru, both presided over the national research councils of their countries. In European countries such as Belgium, a whole series of prime ministers have shown a great deal of interest in the scientific problem and have been extremely well informed about it. This being so, science is very close to policy determination and is also sufficiently impartially placed so that the particular, sectorial interests, can in fact be balanced.

In certain number of other countries, such as France and Germany, the science minister has a dual task. He is minister for science policy and is also responsible for some particular sectors of science. Dr. Stoltenberg of Germany is really minister for science policy, space and atomic energy. This gives him, of course, an executive interest and responsibility for, and probably greater closeness to, the real problems as they develop. However, it does focus his interests in the sense that he has an easier access to science in his own fields for which he is responsible than in fields of the economy, for example, where he has no responsibility. This does seem to lead to a potential imbalance.

Senator Connolly (Ottawa West): If you do not mind my asking, sir, why does the imbalance develop?

Dr. King: Let us put it like this. If a minister has a broad coordinating responsibility in which he has to balance resources, or at least advise on the balancing of resources, between many features of national activity and at the same time he has an executive responsibility for certain sectors, but not for the rest; his natural interests tend to concentrate his efforts on those things which are his responsibility and to pay less attention to those that are not. It is a kind of coordination with a vested interest at the same time.

A number of other ministers of science are, in fact, ministers of education and science. In the Netherlands and Spain this is arranged in such a way that the minister represents science and reports on it at the cabinet, but not necessarily through his ministry. He is minister of education and minister of science and his educational ministry is not concerned with science. This is a rather roundabout way of reaching it, but you will see from what I have said that all these devices have been introduced in various places and are almost always under reconsideration. I do not want to discuss the Canadian situation in any detail because—as you have just mentioned, sir—the OECD is conducting this particular inquiry in relation to science and science policy in Canada in parallel with similar inquiries in other countries.

I have here the report of the United States inquiry and similar reports on France, Belgium, Japan, etc. These have been the subject of much debate in their countries. This is a kind of consultancy exercise whereby a few eminent outside people are brought in to look at the situation in a country and to express their own views on trends, the successes, the failures and to put forward recommendations if they feel like it.

This inquiry by senior examiners follows a background inquiry by rapporteurs on the facts, the statistics, the institutional descriptions and the like; and this is being done at the moment for Canada.

The final episode in the series of events in each of these examinations is a so-called confrontation meeting, which takes place in Paris, where the country under examination sends a group of eminent representatives to defend their position and answer the cross-questioning by the examiners. This was expected for Canada some time early in 1969.

In connection with the Canadian situation, it is not for me to comment on it at this stage. I will have ample opportunity later.

One of the first things usually done is to discuss the statistics of the research and development effort. From the point of view of Canada, this shows an effort less than certain other countries. Judged as a proportion of the gross national product, the United States effort is about 3.4; that of the United Kingdom, 2.3; and Canada, 1.3.

Of course, the significance of such figures is very limited. Incidentally, the Canadian statistics for comparative purposes are very well expressed by a paper presented by Mr. Orr, the industrial research adviser of the Department of Industry, who is sitting at the back of this committee room. Those statistics have been very beautifully presented.

The Chairman: With all the nice colours.

Dr. King: Yes, with all the nice colours. However, the figures do not bear international comparison, because in the case of the United States particularly and in the case of the United Kingdom and France, countries with big defence and big space efforts, the "D" of "R and D", the "development" figures, are very high and consequently swell the percentage.

What is particularly striking on the Canadian figures is that the percentage of the total which is devoted to industrial research is rather small as compared with other countries, that devoted to research by government directly is rather high, and the proportion in the universities is equally high.

The weakness of the Canadian industry figures is striking, at first glance; but it is a great mistake to give too much attention to the relative figures, because they can hide a situation which is worse than appears at first sight.

A small country may have a relatively high proportion of its effort in science, in research and development, as compared with other countries, in a relative sense; and yet the size of the country may be such—and this is true of many European countries—that the number of research and development engineers in that country is perhaps one-hundredth of the number there are in the United States, and so the country has a high relative effort to its total potential effort. It is so small in absolute numbers that choices have to be made, institutional and other devices found, to exploit these resources and make the most of what is inherently a very difficult situation.

In Belgium, for instance, the number of R and D engineers is about one-sixtieth of that of the United States; yet one must remember that the potentiality of science for development is as greatly appreciated in a country like Belgium as it is in the United States. But the possibility of achieving the utilization or the exploitation of the scientific potential is nevertheless very very much smaller and demands that attention be given to problems of international co-operation, to extend resources, and of course selection in both industry and science.

There is a tendency for countries—in spite of the evidence of the folly of pushing this too far—to attempt to be self-sufficient —which is no longer possible. Half the trouble behind the discussions of the technological gap arises from the fact that the total resources of countries such as France, England, Germany, for science are quite submarginal now in relation to the potentiality which scientific discovery and technological application offers to those countries. Consequently, there is a feeling of a gap with America and Russia and there is a recognition of a need for integration, to extend resources and markets.

Therefore, I am merely warning here that the total figures and statistics, as a percentage of the GNP—useful as indicators as they may be—can be very useful for getting money from parliaments at times and they have been employed by many countries, by the scientists and other people—probably completely rightly, in the first naïve stage of insufficient resources and lack of appreciation of what science policy is.

However, it is not enough; it is only a beginning. The resources are made available but the time comes, even if they are sufficiently high when you must ask: "what are they going to be used for, how are they going to be used, how is their creativity to be maintained?" And then all the qualitative institutional and policy questions come in.

Senator Connolly (Ottawa West): Dr. King, do you mind if I interrupt to ask one short question? When you are speaking about Canadian effort and say it is relatively high from the point of view of government, from the point of view of universities, and relatively low from the point of view of industry, had you intended in the course of your remarks to discuss ways and means of increasing the effort which is made in the private sector?

Dr. King: I had no intention of going into this in depth, because it is a very complicated and difficult problem, especially in relation to the foreign-owned industry, which is so important in this country.

The Chairman: And federalism?

Dr. King: And federalism, yes. Perhaps we might come to that during the questioning time.

Senator Connolly (Ottawa West): Thank you.

Dr. King: I have just a few more words about fundamental research. I mentioned the two important functions of basic research; first of all in the educational system and in training; and secondly in maintaining in a country a level of scientific and technological awareness which is necessary if a country is even to know what patents to buy and to apply.

De Solla Price of Yale has done a number of interesting studies on this subject and finds that the proportion of the world's scientific papers, say in chemistry and physics, published by countries runs almost completely parallel with the gross national products of the countries except at the end of the curve. For instance, the proportion of physics papers published by the Soviet Union and the United States is identical with the gross national product in each case. However, there are a few exceptions.

Senator Connolly (Ottawa West): Identical with the G.N.P. applied to scientific work?

Dr. King: That is right. In the case of both America and the Soviet Union the actual numbers of papers published in physics, as a proportion of the world papers in physics, happens to be within two or three per cent of that country's proportion of the world's gross national product.

Exceptions are very interesting. Underdeveloped countries have practically zero. The curve just slips at the bottom. But there are two countries where the proportions of publications in basic research are abnormally high. Those two countries are Great Britain and, still more high, Japan.

In the case of the United Kingdom it would seem that the balance of basic research to applied research is not quite right. This is the kind of problem a science body will try to tackle.

The case of Japan is very important. Japan has been engaged for the last few years in changing from an economy of imitation to an economy of innovation. This is part of a long process whereby the country—the government and its industry—has deliberately, through its educational system, encouraged a higher and higher level of general attainment in its population and an increase in technical attainments as well as in basic research undertaking. This has been done so cleverly that it has enabled Japan, by importing innovations and buying patents and paying for licences, etc., to bring itself to a level of technological innovation which is one of the highest in the world. Basic research and education are regarded by the Japanese as crucial ingredients of this. Also they are ingredients towards the success of the next phase in their development, in which an increasingly larger proportion of their innovations will come from their own laboratories.

I am pointing out these examples to indicate that one should not belittle fundamental research even as a national investment. Its enormous importance for education and for general scientific vitality is recognized. But, particularly through education, its influence on innovations is of quite paramount importance.

Now, there is a point here which I want to put in parentheses. In most countries the relationship between research and education is becoming regarded as of the very greatest importance. I am talking not merely about higher education but also about the educational system as a whole. You may have noticed that in some of the newspaper discussions on the ministerial meeting in Paris, particularly that in the *Economist of London*, stress was laid on the importance of education as probably the main feature behind the technological gap. There is certainly a tendency for education and science to be regarded as a whole, and the need for doing this, will become increasingly apparent over the next few years.

For example, in countries such as many of those in Europe, where principles of democratization of education are regarded as important and where equal opportunity in education is being established, there is a tendency for rapid extension of secondary schooling and university entry and other higher educational possibilities. On the other hand, if this is done merely as a result of a demand of social policy or of consumer demand, it can easily lead to the turning out of many highly trained people with the wrong qualifications in relation to what the economy has to offer and what the economy needs in its manpower at the very highest levels. And this is related strongly to science policy.

Unless, in fact, the educational systems and higher educational systems in their planning are geared to the development of industry and to the possibilities of technology, it is probable that a big unbalance will occur leading to increased brain drains and things of that sort, and intellectual unemployment in some countries. I merely mention in passing that in any serious national consideration of science policy, educational policy cannot be ignored.

I know how extremely difficult this is to achieve in Canada with the educational policy function being so clearly in the hands of the provinces.

Senator Connolly (Ottawa West): It is startling, too, would you not say, doctor, to consider the case of an underdeveloped country sending bright people abroad to acquire high qualifications but then, upon their return home, having nothing for them to do?

Dr. King: Yes. That is another aspect of the same principle, is it not?

Let me, as I go towards the conclusion of my remarks, mention a little bit about what I personally think seems to be the trend in the mechanisms for science policy considerations in countries.

First of all, most countries seem to feel that it is necessary to have a minister and, preferably, a minister without portfolio or without executive responsibility for a particular departmental function, who will be in charge of the general co-ordination and responsibility for science policy as a whole.

As I mentioned, in many countries this is put into the prime minister's office, either directly under the prime minister or under a vice prime minister or a secretary of state within his office. But the function becomes a highly centralized function in government.

In many cases also this minister has an additional function or an additional mechanism to help him with his function. Namely, he is chairman of an interministerial committee.

You have had in Canada your Privy Council Committee for Science. In countries like France, however, the interministerial committees for science meet frequently and are of great importance as major policy organs. The Minister for Science, the Prime Minister or whoever he may be, is thus able to balance politically the demands for scientific utilization of scientific resources of all the other ministries which have an interest in the scheme.

One thing which would seem to be necessary to avoid is having a minister for science who is also at the same time a minister with a specific portfolio. For example, in countries where the minister of education is the minister of science, if there is no other arrangement, it is very unlikely—and experience bears this out—that the utilization of science and industry will be sufficiently strong.

Secondly, in the central level within this minister's office, the tendency is to have some kind of advisory or other council. In most countries this consists of a number of independent people from academic life, industry, economics, etc., whose job will be to advise the minister or Prime Minister or President, whoever it may be, on the broad development of science in the country, to scan the future possibilities, to look at the gaps, to be responsible in general for the forward looking health of science and its application in the country rather than merely to specific activities within the Government.

In a number of countries a second function is given to this group, namely, co-ordination between departments, but I think on the whole the United States system seems to be clearly superior, namely, that in the United States as well as the President's Science Advisory committee there is the Federal Research Council consisting of representatives of main government departments using science and technology, where their programs can be co-ordinated, gross duplication looked at, and so forth. In no country, as far as I know, has such a mechanism led to a really rational distribution of resources, but it does lead to a better utilization than if such a Federal Research Council did not exist.

Thirdly, in support of such bodies there is the need for a central scientific secretariat. This central scientific secretariat should, I think, be multidisciplinary and should not in any way be a lobby for science and should not be the scientists' Trojan horse within the administration. It should be a group whose job is to try to serve the country by utilizing science in the best possible way and to serve science too, but with a balance that is necessary and very difficult to achieve. Such a body should have a number of quite clearly defined responsibilities which are essentially study responsibilities rather than executive responsibilities or those for programs. It should be responsible for the country's statistics of research and development, manpower in the highly skilled sector and at the same time should undertake studies of particular problems and particular fields. It should do reviews of work in progress and it should do some thinking ahead. It should do scanning and forecasting work and should be a so-called lookout institute taking account of newer techniques in technological forecasting and the like. It should give warning of developments and what should be done to meet these developments in advance. It should also be concerned with international co-operation as a method of extending the resources of the country because the cost sharing which international co-operation can bring about does mean that poorer and smaller countries can remain in the new and expensive scientific fields from which otherwise they would be excluded.

This body would also be a link between the scientific side and the educational side. It would advise the financial bodies, the bureaus of budget and the like. In other words this would be a group which by its operational research services and studies, and by its fact-finding operations, its scanning procedures, would provide the basis for decision-marking by the political decision-makers. Also it would feed its material to the various advisory councils and bodies.

Fourthly it is very important to have in the various executive departments of government using science and technology, people of a higher level who have a special function in formulating the scientific elements of the problems of new sectors, identifying new scientific possibilities and responsibility for the application of science. Such science departmental advisers should help to formulate science policies for other sectors.

The Chairman: This would be a kind of interdepartmental committee of officials?

Dr. King: No that is the federal research body. These officials would have their individual function within each department. There must be someone in each department who would be a member of the interdepartmental committee but who within the department would formulate programs to assist in the application of the new knowledge in relation to the policies on these problems.

This fifth piece of mechanism in nearly all countries is a science council especially concerned with basic research as such. It should also help with the allocation of resources to universities for research. Many of these are functions accepted by the NRC here today. In other countries you have the same thing; in France you have the CNRS, conseil national des recherches scientifiques, and in Germany the *Forschungsgemeinschaft*—the Government's mechanism for financing fundamental research. This should largely be left to scientists themselves but of course these scientists must, for this, generate a real sense of statesmanship which is not always the case.

I am suggesting here that we should leave much of the actual distribution and detail to the scientists, but of course the broad lines must be determined by resources availability factors. For example we know quite well that any professor of astronomy nowadays wants to have his own radiotelescope which may cost up to $500 million. Naturally every university cannot have one much less every professor. So at last scientists are beginning to acknowledge the facts of life and are beginning to accept a certain amount of their planning in their own field.

Senator Connolly (Ottawa West): Is this across international boundaries?

Dr. King: Even across international boundaries. The international boundary side will come later, but in the end it will be of great importance.

In the last few years a very good example of the evolution of scientific statesmanship has been exemplified by the National Academy of Sciences in Washington, where there is a reality of statesmanship rather than a series of pressure groups. The Congress of the United States through its committee on science and astronautics by contract and in various other ways asks the academy of science to undertake various jobs, to check up on what the administration is doing and to give a second opinion on many things where they are seeking advice on science and technology. By having such knowledge they are able to see the total picture which is not the case in many countries today. Coming back to what I have been saying then, the suggestion here is that a research council of a country, especially for fundamental and basic research, has a function which cannot in fact be dictated or implemented by administrators but must be based on the judgment of peers principle by using the best informed people available, preferably not restricted to those within the country in question.

At the recent ministerial meeting in Paris, and at its preparatory meetings, there was a strong recommendation for countries to place on their grant-giving bodies and their various panels, a few experts from other countries, to get away from an inbred dividing of the cake between the recognized schools and especially to give the possibility of support to new or younger men who had not yet won complete recognition by the older professors in their country and who tended to be excluded.

Beyond this there is one other feature of science policy institutionalization which I personally regard as very important, namely, the links between science and the body politic as a whole, the links with Parliament. Throughout the OECD countries one hears complaints from parliamentarians that increasingly they are asked to sign cheques for very large sums of money for scientific work, without having any real opportunity of knowing what it is for, whether it is the best of several alternatives, and so on.

This is a very difficult situation, and one whose solution is certainly a matter of information and education. A number of countries have created scientific and parliamentary committees where scientists and parliamentarians discuss things together, and gradually there is an understanding between them.

In the United States Congress the Committee of Science and Astronautics has its own advisers and meets with them regularly. I have a report here of one of their recent meetings where, among other people, Dr. Solandt was one of the advisers of the congressional group.

In a number of other ways parliamentarians are gradually getting into better contact with science issues but it is a difficult process. In many countries one or two parliamentarians seem to be emerging who take a special interest in the subject and have educated themselves very deeply in it. An outstanding case in question is that of Congressman Daddario in Washington, who has achieved great respect among scientists for his wisdom and impartiality. I think it would be a great pity to neglect this relationship of science and parliament in the total thinking on science policy, and some provision, formal or informal, should be made towards it.

In conclusion, Mr. Chairman, just one or two words on future developments. The primary feature about what we are up against now is the complexity of the problems we face. May I illustrate this by our recent discussions and studies in Paris on the technology gap. This technology gap between the United States and European countries, particularly, was a subject of much misunderstanding, and I think our meetings succeeded, to some extent, in demystifying it; it was clearly not so much a technology gap but much more a gap in capacity for innovation. But it was very early evident that it had important elements of a direct economic character—size of country, size of markets; it had subtle economic characteristics in relation to capital availability—attitude of the merchant bankers and availability of risk capital; it had extraordinarily important facets of management capacity and the like; it had great elements of direct, ordinary background education which was creating the differences; and, as well as that, the important problems of the approach to the development process—pilot plants and the like, and the total research resource availability. This seems to me to be the kind of problem we will have more and more in the future, and in nearly all the discussions of this subject at which I was present—and I can assure you I had more than I would have welcomed—it was rather easy for people to provide a number of self-evident and almost naïve but sensible solutions in relation to each element of this problem, but what was utterly impossible was to find anyone who could understand sufficiently about the relative importance of an interaction of these elements—capital flow, management skills, education, technology—to give a coherent trend towards a solution of the problem in its entirety.

This is an increasing difficulty for those who are legislators and for managers everywhere. Increasingly, governments, in particular, are faced with overall problems of this type of complex nature which they must tackle for the sake of the health of their societies and economies.

The Chairman: Would you call that the Human Sciences gap?

Dr. King: It is more than that. The whole of this is sociology, really, but the first thing is, as you say, that these problems are multidisciplinary. The Natural Scientist is quite impotent against these problems, and yet he has some of the most interesting approaches and new ingredients towards their solution. The economist is a long way from a solution. The behavioural scientist seldom gets the opportunity of tackling them, and when he does he does not know what to do. The manager, by himself, cannot do very much without the other skills, and it is so seldom that one can bring these skills to bear at the same time and at the same place. The various professional distortions of all these groups add to the confusion.

In our work in OECD we are faced with this problem of the disciplines—the naïvety of the natural scientist, the arrogance of the economist, the ignorance of the politician, the complacency of the administrator—and between these, we all, with our own distortions, are trying to solve problems which are multi-disciplinary, which even with the computer we cannot quantify, and yet we as people concerned with Government and decision-making have to find answers to this problem.

The future has many problems of this nature in store for us—far too many. Take the subject of education. It has reached this complex stage. Changes in education do not now come primarily from the research of the pedagogue in the educational schools, but from the economist, the statistician, the psychologist and sociologist, and even the physiologist. Further educational development cannot take place in isolation; it is associated with the economy, the aims of society, the aims of equal opportunity, but also our long-term economic goals. Many of these complexes of problem are now facing us, for example, those of urbanism and transportation. They all need this multi-disciplinary approach; they need new techniques such as those developing in the United States, and elsewhere, of technological forecasting. Such problems are of direct concern to governments and nearly all of them cut across departmental lines and compartmentalization. They need new approaches, new groupings, regroupings and a *souplesse* which our ordinary bureaucracies do not really supply.

This is a warning for the future, but this future is really tomorrow's future and not that of the year 2000. We are already facing these problems.

I am ending up here because this brings me right back to where I started. Science is a sub-system of the national system. It impinges on all the other sub-systems of policy. But, unless the national science policy of a country, or, as I would rather have it, a national policy on science and technology, has a breadth, an understanding, a depth, a sense of interrelationship, and a multi-disciplinary approach, then that country will be in a situation where it is looking at fractions of each problem. This is particularly to be the case for highly industrialized societies. It is one of those cases you suppress a symptom and find that another symptom arises. We have got to develop somehow in our countries a science policy which can in this multi-disciplinary comprehensive way understand these problems, and attach them in their entirety.

The creation of such policy is not easy, but when you are reviewing your situation and your own organization, please try to do it in the perspective of at least the next 20 years, and realize that quite new types of need are here already, although not always under government inspection.

In respect of subjects like education, in a country like Canada, the problems facing you, with all of your advantages, are going to be really formidable if you are going to deploy your human resources and develop your individual possibilities without frustration.

That is all I wanted to say, Mr. Chairman but I am afraid I have complicated rather than simplified your task.

The Chairman: I think the contrary is true, sir. Before thanking you very much for this most stimulating presentation in terms that would be justified, acceptable, and appropriate, I am sure that the members of the committee will want to ask you some questions.

Again, this afternoon, I shall start with the senator sitting to my extreme left, Senator Grosart. He is, for most of the time, close to the left. I might add that he is missing one of his colleagues, who is probably out campaigning, today.

Senator Grosart: You are referring to the Tory left, I presume, Mr. Chairman.

Dr. King, you warned us about the complexity of the subject in relation to science policy. We have had this warning before. I am wondering if there is not a tendency in this field to exaggerate a bit.

Of course, there is a complexity in the political decision-making process everywhere, whether it is in relation to external policy, sociological problems, and so on. The same complexity, it seems to me, exists in all kinds of considerations, and I am beginning to wonder, in listening to the evidence given before this committee, if the problem is not being over-exaggerated, largely because of the newness of the subject, which you yourself pointed out.

Scientists, it seems to me, are now joining the ranks of those who successively have felt the sudden impact of political decision-making on their particular field. By and large these other people have at some stage got together, worked out some of these problems, and presented some kind of a consensus to the political decision-makers.

For example, in the field of industry one tends to expect to hear the industry viewpoint from a national association of manufacturers and a chamber of commerce. We hear from the lawyers through the Bar Association. Quite recently our universities, which have felt the impact of political policy-making, have got together and presented to the policy-making body some kind of consensus.

I am not questioning your judgment, of course, but I am a little concerned about your suggestion that there should be so many different bodies to represent science in the policy-making mix. You have mentioned a minister, an advisory council, a science council, and a research council. How is the political decision maker going to decide if he has to listen to all of these people?

On the other hand, you used such phrases as "a science policy body which will determine", and so on. You said that one of the problems you see is in the fact that most countries have no single person with a responsibility for the totality of the problem. You said, in connection with the science secretariat, that it should provide a basis of political decision or policy making.

Is it not possible that the solution to this problem of science in policy, if you like, may be less complex than seems to be the case in most countries? Is there not some easier way for the political decision maker than that of consulting all of these bodies and wondering to which of them he should listen?

The Americans have simplified this matter a bit by having a science and technology adviser to the President, and of also having a scientific advisory body that has independent access. They seem to have narrowed down the procedure. Is this a trend?

Dr. King: Well, first, naturally I have to exaggerate a little to make my points. Many of the complex studies I have described are very real, but they are examples of the generally increasing and diversifying responsibilities of government which are difficult to avoid in the kind of world development we have today.

With regard to institutional solutions, the ones I suggested are of course very general and very tentative. I do not think they are really as complicated as their enumeration may have indicated. I think that within any department of government there are a number of levels or organs which, if described in detail, would appear to be very complicated.

In the United States, as you say, they have simplified this a bit by putting several of these functions into the same office, and by having a single individual handling a number of these functions but clearly keeping them separate. For instance, Dr. Horning is the direct adviser to the President. He is also the chairman of the science council.

Senator Leonard: The advisory committee.

Dr. King: Yes, senator, the President's Scientific Advisory Council, the CPSAC. He is also the chairman of the Federal Research Council and he is head of the Science Secretariat, so these things are all brought into one office, but the functions are no less clearly differentiated within that office. I do not honestly think it is a very complicated situation. In most countries at present the basic situation is more complicated because there are so many separate decision making points; they are not interacting; it is only occasionally that they do come together.

Senator Grosart: Do you see these science ministers without portfolio as a single body which will bring the decision to the policy makers?

Dr. King: On the general policy, yes, although, as I have been trying to explain, the impingement of science on many other government functions will be greatly determined by decisions made in these separate departments. One cannot escape that.

Senator Carter: Dr. King, you said that the trend now was away from central ministries of science. In a country like Canada, having regard to our geographic vastness would that preclude setting up a science secretariat, do you think?

Dr. King: I feel—this can only be a personal opinion—that the general trend is certainly away from central scientific ministries attempting to do the scientific elements of work which is normally distributed between many ministries. Nevertheless, I was advocating very strongly a central scientific secretariat, essentially doing preparatory, survey and study work, leaving the execution and direction of science to different agencies attached to the mission-oriented organs of government.

Senator Carter: You mentioned some figures, namely 2.3 for the United Kingdom, 3.4 for the United States, with Canada way down at 1.3. Have you any statistics to balance the achievements against these figures? You gave achievements in the case of Japan and Britain which were abnormal. I do not see how percentages like this can be very meaningful unless you can at the same time see what these figures have achieved. Is there any answer to that?

Dr. King: Definitely no, sir. You have put your finger on a very, very sore point, because in the discussion of R. and D. statistics it is always input figures and never output figures, except where attempts are made by counting scientific papers or counting patents. Counting scientific papers, if qualified by citation surveys—i.e. how often a paper is quoted by other scientists, which is a mark of quality if you like—does give a measure of the output for basic research, and on the whole I think we can see that the output figures there are more or less parallel with the input figures in many countries. When it comes to applied science or the application of basic science there are no satisfactory output figures. Attempts have been made in terms of the so-called technological balance of payments. How much does a country pay other countries and firms in other countries by way of licences, for know-how, and so on, compared with what it gains? The statistics themselves are very uncertain, because the direct relationships between firms does not permit such payments to be carefully analyzed. Technological exchange may slip in as an extra in some bigger negotiations and never appear as a sum anywhere at all, so there are no reliable output figures. General discussions, for example, in parliaments, of the successes and failures of major technological efforts—e.g. British aircraft or French computers are generally broadly assessed on overall sales figures for the products, or else are purely subjective judgments.

The Chairman: Senator Carter, when we hear the federal research agencies it is at least my intention to ask them to describe what in the last five years have been their five big failures and also their five big successes.

Dr. King: And the reasons for this?

The Chairman: We might come to that in the second phase of our inquiry.

Senator Carter: I was asking Dr. King because the OECD is making a survey of Canadian science now. I was wondering if they were going to look into that problem of achievement of output as well as the input.

The Chairman: Have you gone into these things in your previous reports?

Dr. King: Only in a rather general sense. It is almost impossible to do so with the time and effort available.

Senator Carter: You mentioned international cooperation. In a world where we have two giants, the United States and Russia, with tremendous resources and tremendous scientific resources, having regard to the importance of basic research through industrial development and economic development would you think it possible for NATO as an organization to develop a policy of its own, to cooperate in developing a NATO program of research and development to balance off the other two? Or could that be done by OECD or in some other way? I should like to get your opinion on that.

Dr. King: From a practical point of view it could be developed by NATO, it could be developed by OECD, it could be developed within the six countries of the Common Market in certain fields. We have enough institutional knowledge to know perhaps how it should be done in many ways. It depends, however, entirely on the will of governments to do it and to choose the organization which they wish to do it. So far many of the international cooperation schemes have resulted from the success of pressure groups. In a few cases they have resulted from purely, shall we say, political initiative. For example, the creation of the International Cancer Research Institute at Lille was the result of definite political initiative by the French rather than scientific initiative. CERN at Geneva is one of the best and most successful examples of purely scientific initiative. International scientific cooperation can be established and can be successful. The question is whether there is a collective will of governments to do so. On the basis of recent discussions in Europe, that will does not exist at present or is not sufficiently coherent.

The six countries of the Common Market are attempting to undertake cooperation and research, experimentally at first, in about five or six major fields, but they have got very little way so far. In OECD we have tried to establish cooperation between groups of countries willing and wanting to pay for this cooperation together, but on rather minor topics. The need for this in years to come will certainly increase; as the cost of research soars, the need for cost sharing becomes evident.

The same thing is felt by the Eastern European countries. It is clear, for example, that there is a good deal of dissatisfaction among many of the Eastern European countries at the lack of concerted cooperation which is developing between them, with the inflexibility of their systems to enable this cooperation to take place. As I say, we do know enough now about how to do it, but its success is entirely a matter of political will, and in my judgment that does not exist at the moment.

Senator Leonard: Mr. King, would you mind telling us what is the present United Kingdom set-up on the question of science policy?

Dr. King: It is a fairly complicated setup. As I indicated earlier, there a division is made between education and science, including basic research on the one hand and technology on the other. Until about three years ago, the situation was quite otherwise, but the British felt there was a need for reform, and instead of having a Minister for Science as they had then, they created a Minister of Education and Science on the one hand, and a Minister of Technology on the other hand. This was a direct recognition of Mr. Wilson's insistence on the importance of science and of technology in the revival of the economy.

It works out in the following way. In the Ministry of Education there is a secretary of state, a number two minister for science and higher education.

Senator Leonard: That is Lord Snow?

Dr. King: No, Lord Snow was in technology. This was Lord Bowden. It is now a lady, Miss Shirley Williams, who is an outstandingly intelligent young economist.

This group in the Ministry of Education has of course an advisory council attached to it. Amongst other tasks it supervises the funding of universities for research, special scientific and technical grants, studies particular scientific problems, is concerned with policies for the diffusion of scientific information, et cetera.

The Ministry of Technology has a number of major technological tasks, e.g., in relation to the aircraft and computer industries. In addition, it operates a number of national laboratories of various kinds—e.g., for building research, and for water pollution, air pollution, mechanical engineering, the National Physical Laboratory, the Royal Observatory at Greenwich, and others. It also supplies the governmental resources for a large number of research associations for the various industrial sectors.

The Minister of Technology has also his advisory council, the chairman of which is Professor Patrick Blackett, whom I think you interviewed recently. Many people are uncertain as to whether this is the right solution.

Some time ago, the Prime Minister set up a Superior Advisory Council to himself, under the chairmanship of Sir Solly Zuckerman. It is supposed to be the paramount science policy group, but so far we have not seen any results.

Senator Leonard: The setup you suggested as being the proper one, is one quite different from the present setup?

Dr. King: Yes, the setup of the Zuckerman Committee was a tendency away from the one I mentioned.

Senator Leonard: Instead of the Prime Minister, you would like to have a Minister without Portfolio, with no executive responsibility, to be in charge of this matter of science?

Dr. King: Yes, but in a central position and closely linked to the Prime Minister.

Senator Leonard: Assuming some setup like that in Canada, a Minister without Portfolio, with an advisory committee, and a coordinated departmental council with representatives from various departments, to coordinate, and with the Science Secretariat, where would organizations like the National Research Council fit into that?

Dr. King: The National Research Council, in accordance with what I have suggested would be the grant-giving body for fundamental research and for undertaking certain other things determined by the minister, by agreement, and it would report again to the same Minister without Portfolio. This is exactly the situation in France and Germany. Its exact scope and functions would have to be determined in the light of the special political and geographical conditions of Canada.

Senator Leonard: Thank you, Dr. King.

Senator Yuzyk: Dr. King, it is very obvious that science is international in scope and impact, and that many of the countries would not be able to make the progress that they would like to make, unless there is this international co-operation which has been discussed. I can foresee the day that we will have to do much more through the United Nations. I am entirely ignorant as to whether the United Nations has begun at all to tackle this problem of the international co-operation, particularly with respect to certain fields such as health for all of humanity, for the whole world. Has anything been done, to your knowledge, by the United Nations to deal with this problem of international co-operation?

Dr. King: Oh, yes, quite a lot. I am afraid this will be a matter for another hour or two, there is so much that has been done.

Senator Yuzyk: Just a brief outline?

Dr. King: The main instruments here of course are in the Food and Agricultural Organization and the other specialized agencies such as the World Health Organization, and particularly UNESCO. The functions of WHO have been so clearly defined that the work is rather well developed, but not very strongly.

A number of attempts a year or two ago to create an international biological and medical laboratory under WHO was not finally accepted.

UNESCO, on the other hand, has had a great deal more to say in all of this. First of all, it has provided a kind of service, especially to the less developed countries, on the building up of science policies. It has had many attempts at creating international laboratories. For example, this body CERN in Geneva—*Conseil européen des recherches nucléaires*—was created through UNESCO. It also created the international institute for calculations, at Rome.

Then we must remember, in addition, that UNESCO is the main subventor to the International Council of Scientific Unions (ICSU), and through it, such activities as the International Geophysical Year, the Quiet Sun, Antarctic programs and many other big scientific schemes have been developed by the scientists themselves, but working in a general sense within the UNESCO framework.

There have been many other projects and suggestions, e.g. for an international centre for the study of the brain, but these have not got very far. One of the recent difficulties is that, the United Nations agencies being dominated, to the extent of four to one, by the votes of the less developed countries, the tendency is that they become Technical Assistance bodies, and they find it difficult to work at the level of sophistication of interest of countries like Canada, Sweden and Switzerland. The tendency in recent years, therefor, has been away from the type of activity you are mentioning, away from the problems of the highly developed societies, towards the problems of the less developed societies. In Europe, probably with good and bad examples, more or less favourable, there is the creation of CERN, which has been outstandingly successful; and the creation of ELDO, the creation of ESRO (the European Space Research Organization), the two space bodies; and the recent creation of EMBO, the European Molecular Biology Organization; and dozens of other smaller activities. The sheer political fragmentation in Europe is driving them in the direction of cost sharing. In the eastern countries similar cooperation is taking place, e.g., in Dubna, the Russia nuclear centre.

Therefore, I think one can say that we will see in the future much more of this kind of international co-operation, developing, between groups of highly developed countries, rather than exclusively within the United Nations framework.

Senator Yuzyk: So far it is more regional than international?

Dr. King: Yes.

Senator Yuzyk: Are there any instances, to follow this up, of co-operation between the two warring nations, that is, the Soviet Union and the United States? Has there been any basis laid for any kind of co-operation?

Dr. King: On a bilateral basis, yes, but not through institutionalized multilateral arrangements. There are innumerable bilateral projects, of course, and the Soviet Union joins in a number of the UN special schemes, the geophysical years, and so on, with the others. There have been American suggestions for co-operation on space problems, not really followed up. There are a number of cases, but on the whole they are rather marginal so far.

One of the successful examples of East-West co-operation is again, CERN in Geneva. This nuclear physics body accepts workers there from eastern countries and particularly America as well as from its Western European members.

In a recent meeting that one of my colleagues attended, there was a statement made by the Polish representatives that their cooperation through CERN with the western

European countries, although a body of which they were not official members, was so much-more effective than their co-operation through Dubna, an organization of which they were members.

This may tell us something.

Senator Yuzyk: It very well may.

Senator Thompson: Dr. King, from sitting here and listening to the various witnesses who have appeared before this committee, I have come to feel so completely like a cog with a whole new world opening up before me in which there are more or less an elite or an aristocracy making the decisions. But simple fellows like myself, and other citizens in a country, are not aware of the enormous potential that new scientific discoveries and research can develop to be of benefit to us and influence us.

You had mentioned that in the Congress there was one particular congressman who took a great deal of interest in this.

Frankly, I learned here that Canada was going to go in for a communications satellite and had decided on it. But this was not brought to me as a citizen through the newspapers to consider it. I did not see it on our national communications network. I do not see it on the platform of a political party.

I ask you this, going back to Senator Grosart: it would seem to me, as a politician, that I may suggest to a province, for example, that, "We will build a road through here, and these are the benefits you are going to get. You can choose whether you want a road or whether you want some hospitals."

With scientific research, it seems to me, decisions have been made without the public being drawn into making an evaluation. I suspect that it is almost by accident that we are all racing along in space research. Sputnik went up. So the United States came in. Again a group of scientists made decisions rather than the general public.

I am sure there is a real concern, as I have heard, in connection with trying to get this to the public, trying to get all the complexities involved in scientific research across to the public. It may make it hard to get the public to understand the benefits they can get and also all the problems attached, but are these seminars, for example, for newspapermen and for the publicity media? Are there P.R. people attached to the science councils so that they can relay this information across to the general public?

Dr. King: Personally, I agree very strongly with what you have said. I think many of the new scientific programs grew out of the acceptance of the large effort in nuclear energy during the war, which had by its very nature to be kept secret. This set an example for decision making in which many parliamentarians were in fact completely out. The data could not be placed on the table in the way it normally was, and this may have set a bad example.

On the other hand, I would say that there are very good features on this now as well. I think that the American space programs have so accustomed the general public by their prestige importance, if you like, to supporting big programs that the time has now come when Congress and the public in the United States will accept very massive expenditures on problems of human and national amenities, and on the preservation of the environment against air and water pollution and of solving the problems of urbanization and transportation with the same sort of strength and effort as went into some of these earlier military things.

I would suggest that we are passing through a transition stage and coming back to a much more normal way of dealing with things and making decisions with public support. I think personally the press has an enormous place in this. In so many countries responsible and highly informed pressmen are emerging who are doing very good jobs on this.

In OECD, for example, we had a very interesting two days with the press, just before the recent meeting of Ministers, where the science directorate, described in detail all its work in science and education. The debate was extremely well informed. I suggest that just as desirable as the international case about which I am talking, is its national counterpart. So I can really say that I agree.

The Chairman: I am sure that the press has noted this.

Senator Thompson: I am sure there is a trend to have someone with a background in science in both newspaper and television fields.

Dr. King: Yes.

Senator Thompson: Do you find that to be true around the world?

Dr. King: Yes, that is a regular trend. It is very definitely a noticeable trend.

Senator Kinnear: Mr. Chairman, I too belong to the class of non-scientific minds. I hesitate to say "the ignorant politicians," but I feel that that is exactly where I belong.

However, science is galloping along at such a rate, particularly at the one end of it, that it is difficult for me to think of what can be done very shortly. I am interested in the field you just mentioned. I am very much interested in the humanities and in the survival of people from impure air and water, from improper housing, and I am very interested in the poor of the country. I am glad to hear you say that the Americans are now willing to spend great amounts in these areas, and I would like you to be able to tell us how you feel Canadians can look after the matters I have just mentioned.

Dr. King: I think, senator, that that is an unfair question.

The Chairman: If you answer that one correctly, sir, you should be a candidate for the prime ministry.

Senator Yuzyk: Yes, you should be the Prime Minister of Canada, if you can answer that one.

Dr. King: If I attempted to answer it, I think it would be unjust interference in the affairs of a foreign power.

Senator Kinnear: That is all right. Let us hear it.

The Chairman: You attach great importance to this area?

Dr. King: I attach great importance to it, but how it would be done here I have no idea at all. I do not know how the Canadian public reacts to these things or how it is being done here.

Senator Kinnear: I will leave the word Canadian out. How would you go about doing it for the world? That is the important thing we have to consider. We have to look after the poor of the world.

Dr. King: May I answer not in terms of poverty but with respect to some of the other amenities? In OECD we are trying to look at questions of urbanization, and water and air pollution and so on. We are trying to get coherent policy groups going on each of these subjects which will have a number of international connections.

For instance, we have stressed the importance of the management of water research and the creation in countries of single authorities that can do it, and the encouragement of them to get out research programs and then, subsequently, between them try to arrange joint research plans.

For instance, there will be a meeting held in Stockholm next month at which there will be a discussion of the problems throughout the world of the pollution of the Great Lakes. Obviously the United States and Canada are very strongly involved in this question, but there are other lakes such as Lake Geneva and Lake Constance in Europe and the lakes outside Stockholm in Sweden which are in the same position as the North American Great Lakes.

There is everything to be said for the people trying to look at this to come together to try to establish joint programs and get accumulated experience which in their own countries would take ten years but which, by means of this joint effort, would take only half the time and would give much richer data.

In the same way, on air pollution we are trying in Europe to set up a series of, first of all, background stations in typical places where there is no special pollution, but just to keep track of the gradual increase in the amount of, for example, D.D.T. in the area, and all the small encroaching menaces which though not yet important enough to be scandals will undoubtedly develop into such. In this way we will have a regular knowledge of the whole problem. These will be established together with a number of acute stations, places where special pollution is expected.

This is still in its formative stages, but the idea is to set up a network of such stations which will accumulate knowledge so that it will be possible for countries to base legislation on the actual facts and the probable situation in the future and not merely waiting until it is too late or until there is a disaster situation to tackle. As far as poverty is concerned, I am a physical scientist—I am one of the naïve type I mentioned earlier, together with the ignorant and the arrogant—and not being a social scientist I would not know where to start on this problem. As an individual or as a citizen I might have some ideas, but I don't think I should start to talk about it here.

Senator Grosart: To what extent in various countries are the legislative bodies participating in the decision-making as between science expenditures and the selection of expenditures within scientific projects, or is this too big for the parliamentary representative process?

Dr. King: It is very difficult to say directly, senator, but I don't think they are participating enough. I think the Congress in the United States is possibly the one which has gone furthest here because it is definitely asking the questions. Until a few years ago through the prestige of the bomb and the man in space and all the rest of it, science was a good thing and could on the whole get more money, but the sophistication which has come into Congress now is such that they are asking for greater information. They want to know for what and for whom and how much. It is not even relying completely on the administration's arguments; it is having the National Academy of Sciences do special checkup studies and so on so that it tells what as far as possible, are the basic elements without which decisions cannot be made rationally. I think there have been enormous advances in Washington over the last three years particularly. In the British Parliament again there are at least half a dozen people who know a great deal about this kind of thing and in the committee on estimates and in a number of other committees their influence is being felt so that there is a rational approach to these subjects. In the British House of Lords, especially with the addition of life peers, the scientific lobby is very often—and in a non-party type situation —producing a degree of expertise in parliamentary circles which is greatly superior to what we had five years ago. In the French Parliament again there are a number of people while in the German Parliament they are fewer, but the German parliamentary scientific commission is beginning to exert influence but not sufficiently quickly. There is also an interesting international approach in that the assembly of the council of Europe, the parliamentary assembly of the council of Europe, has a committee for science and technology the chairman of which is a Swiss parliamentarian, a humanist, a Greek scholar, Professor Reverdin, who has been recently elected President of the National Research Council of Switzerland. This man is a devoted scholar who is also a good parliamentarian. He is doing an excellent job and has a secretariat behind him in keeping parliamentarians informed of the scientific development in Europe. The group meets, I should think, eight times a year and has a constant literature and documentation service to keep it informed of new events. It is pressing hard for a European science policy, apart from the formation of a lot of small committees. Something is being done.

Senator Grosart: Do other countries with which you deal have standing committees of the legislatures dealing with science and science policy?

Dr. King: No, sir. Very few of them have. Most of them have these semi-formal parliamentary and scientific committees. About three years ago OECD and the Council of Europe jointly held a meeting of parliamentarians and scientists to try to encourage the greater penetration of scientific information to parliamentary circles. It was quite a successful meeting. Canada did not see its way to participate, but that is another thing. This meeting led to the formation of quite a number of other parliamentary groups of this sort. In Great Britain for instance the parliamentary scientific committee created by Viscount Samuel, the Liberal leader, before the Second World War, over a period of 30 years has a magnificent record of influencing legislation in a sense of providing better information, and very often bi-partisan study of difficult technical problems of legislative significance. Its influence has recently become less. The three main political parties in Great Britain have their own party scientific committee which consists of a mixture of members of Parliament with outside scientists who belong to the party concerned and these political party scientific committees have done a great deal to increase the interest of the platform in scientific and technical matters and as to the action that should be taken.

Senator Grosart: That is in suggesting priorities and choices?

Dr. King: Priorities, choices and general policy trends which the party might support. Both the Labour party and the Conservative party have rather strong groups of this sort at the moment.

Senator Grosart: On the OECD statistics, do you at any stage go beyond the raw statistics, the figures that have been quoted here, and take into account such things as the inflow of scientific expenditures into Canada, for example, from our United States companies operating here or say in Europe under the NATO infrastructure and things like that? Do you at any time refine these broad figures?

Dr. King: Yes, sir. The figures which are mentioned at the moment are mainly derived from the several analyses of the data gathered during this international statistical year of R and D. The first report published is essentially the global figures. There will be other reports published this year, one analysing the industrial sectors which we deal with in as great depth as we can, and another will deal with the division between various fundamental sciences and the rest. It has so far not been possible to estimate future expenditure very greatly, but an attempt will be made—perhaps in the next statistical year—to make provision for all this and especially in the meantime to do one or two in-depth studies of samples to see how it could be done. Secondly, an effort will be made to ascertain the figures in the social sciences. This is the present intention.

Senator Carter: With respect to basic research, Dr. King, are there any figures which measure in any meaningful way the spin-off from basic research, the value of the spin-off in terms of new industries and new products, etc?

Dr. King: As far as I know there are no general figures of that sort. A number of attempts has been made to do a kind of cross-benefit studies on particular institutions and to evaluate the research they have done in terms of hardware or whatever it may be. But so far it has not been terribly impressive.

Senator Carter: Is there any significant research done in European countries by private industry alone, without any Government support whatsoever?

Dr. King: Oh yes—firms like, say, Imperial Chemical Industries in England, or Philips, the big electric company in the Netherlands, or Shell in the Netherlands.

Senator Carter: Would it be of significant proportions?

Dr. King: Quite.

Senator Carter: Thirty per cent, 40 per cent?

Dr. King: The figures on this are known, are available. It is quite considerable. Some of them are in fact in here. Perhaps you could look at this later, rather than spend time fishing them out now.

Senator Carter: Yes.

My last question is, when you come to make a decision in a fundamental research project which is supported by Government which is, perhaps, not producing apparent results, that seems barren, which seems to be working up a dead end, and someone has to make a decision whether you continue it or terminate it, what is the machinery most commonly used to arrive at that decision?

Dr. King: Generally, the research director himself. If it is basic research...

Senator Carter: Yes, basic research.

Dr. King: ... he is generally the only person who is aware of the fact it is coming to a sterile area, and if he is a good research worker he will either stop it, change ground and try other approaches, and so on. I do not think anyone from the outside can tell him what to do. He knows that if he goes on his own reputation will suffer, that he will have very little to publish, and that what there is will not get him any credit. So, I think all the factors are operating to make him stop.

What is much more difficult is deciding when to stop within government or industrial laboratories because, especially when one is undertaking research which is intellectually interesting, the tendency is to go on with it because it is interesting, but you know quite well its application possibilities are rather remote. To stop such work is a very painful and difficult decision, but that must be made by the director of the laboratory or the grant-giving organization which is behind it.

Senator Carter: This would not be a decision made by this Minister Without Portfolio?

Dr. King: No, this Minister Without Portfolio would not be able to, and should not try to interfere with the actual direction of individual research.

Senator Carter: Thank you.

Senator Leonard: I have no more questions.

All I wish to do is to express my gratitude and, I am sure, that of all the other members of the committee to Dr. King for one of the most informative and valuable contributions we have had. I am certainly very grateful to him for his presentation this afternoon. It was wonderful, Dr. King.

Dr. King: Thank you.

The Chairman: I know that Senator Leonard has expressed the views of all members of the committee. I am sure, Dr. King, that you will understand the special position of this committee this afternoon, but we are most grateful that you could come under these most unusual circumstances. Thank you very much.

Dr. King: Thank you.

The meeting adjourned.

APPENDIX

THE CANADA COUNCIL

SOCIAL SCIENCES AND HUMANITIES PROGRAMME

	Actual			Estimated	
	1964-65	1965-66	1966-67	1967-68	1968-69
	($000)	($000)	($000)	($000)	($000)
Research training—					
Doctoral fellowships	695	1,181	2,931	6,575	x
Research—					
Post-doctoral fellowships ..	—	—	—	144	x
Sabbatical fellowships	177	305	617	906	x
Research grants	203	412	983	2,100	x
Killam grants	—	—	—	—	x
Publication grants	94	138	293	250	x
Meetings and Exchanges ..	59	150	147	200	x
Research Collections	45	565	500	1,000	x
Special Awards & Grants ...	54	89	83	116	x
Adjudicators' fees and expenses	7	32	59	75	x
Aid to foreign students and scholars	69	245	225	248	x
Total SS & H Programme	1,403	3,117	5,838	11,614	17,188
Total Canada Council Budget less University Capital Grants Fund	3,511	7,556	11,385	20,442	28,409
NRC—MRC Budgets	26,050	33,570	52,750	69,800	92,700

LIST OF WITNESSES

BIOGRAPHIES

MEMBERS OF THE COMMITTEE

AIRD, HON. JOHN BLACK, B.A., Q.C., (*Toronto*). B. May 5, 1923 at Toronto, S. of Hugh Reston Aird and May Black both Can. Ed. Upper Can. Coll., Univ. of Toronto and Osgoode Hall. M. July 27, 1944 to Jane, Dau. of Harry B. Housser of Toronto. Four children: Lucille E., Jane V., Hugh H. and Katherine B. A Lawyer. Served as Lieut. R.C.N.V.R. 1942-45. Partner; Edison, Aird & Berlis; Vice-President and Director The Algoma Central Railway; Director, Bank of Nova Scotia; Canada Permanent Trust Company; The National Life Insurance Company of Canada; Consolidated-Bathurst Limited; American Metal Climax, Inc. Summoned to Senate November 9, 1964. Party pol.: Lib. Rel.: Anglican. Address: 2 Glenallan Road, Toronto 12; Business: Suite 914, 111 Richmond Street West, Toronto, Ont.

ARGUE, HON. HAZEN ROBERT, B.Sc., (*Regina*). B. Jan. 6, 1921. S. of Howard B. Argue and Legia Scharf both of Irish descent. Ed. at Avonlea Public and High Schools and Univ. of Sask. M. July 24, 1945 to Jean dau. of Arcade Ignatescu of Kayville. A farmer. Graduated with distinction specializing in Farm Management. First elected to H. of C. g.e. 1945. Re-elected g.e. 1949, 1953, 1957, 1958 and 1962. Def. g.e. 1963. Chosen Leader C.C.F. Party at National Convention, Regina Aug. 11, 1960. Summoned to Senate Feb. 24, 1966. Party pol.: Lib. Rel.: United Church. Address: Kayville, Sask.

BELISLE, HON. RHEAL (*Sudbury*) B. July 3, 1919 at Blezard Valley. Son of J. B. Belisle and Philomene Nault (French Canadian). Married Aug. 21, 1941 Edna Rainville—8 children. Educated at Blezard Valley, Chelmsford and University of Toronto. Councillor, Township of Rayside, 1945; Reeve Township of Rayside, 7 years 1946-52 inc.; Clerk Treasurer of Rayside Township 2 years; President and Director of Sudbury and District Municipal Association; Director of Sudbury and District Home for the Aged; Director of Sudbury and District Chamber of Commerce, 1950-55; Director, Chelmsford & Valley Chamber of Commerce, 1952. During World War II served with the Canadian Army, 1941-43. Entered the Legislative Assembly of Ontario in the new riding of Nickel Belt at the General Election, June 9, 1955. Re-elected at the General Election, June 11, 1959. Secretary of Nipissing and Sudbury P.C.'s, Vice-President of Sudbury and President Nickel Belt. Godfather of five universities. Summoned to Senate, February 4, 1963. Represented the Canadian Senate to NATO Conference in Paris, October-November 1963. Visited NATO military installations in NATO countries. President of Sudbury Insurance Agency. Director of Belden Corporation Limited. Director of Fielding Lumber Co. Ltd. Chairman of the Board of Governors of University of Sudbury. On December 1, 1964 was delegated to represent the Senate at the 19th Session of the General Assembly of the United Nations, New York. April 24, 1965 named for Life, Honorary President of L'Association D'Education d'Ontario. October 4, 1965 represented the Canadian Senate to the 20th Session of the General Assembly of the United Nations, New York, when Pope Paul visited the United Nations. Party Pol. P.C. Rel.: Catholic. Address 403 Simpson Road, Ottawa.

BOURGET, HON. MAURICE, P.C., B.Sc.A., M.E.I.C., Ing.P., (The Laurentides). B. Oct. 20, 1907 at Lauzon, Que. Ed. Commercial Academy, Quebec, Lauzon Coll., and at "Ecole Polytechnique" of Montreal. A consulting engineer. Mem. Bd. Dir. of British Nfld. Corp. Ltd. and Hall Corp. of Can. Member Engineering Institute of Canada; Professional Engineers' Corporation of Quebec. Elect. to H. of C. at g.e., 1940 and re-elect. at g.e., 1945, 1949, 1953, 1957 and 1958. Parliamentary Asst., to the Min. of Public Works, Oct. 14, 1953 to 1957. Can. Del. to U.N., Paris, 1951. Can. Del. Gen. Conf. of Commonwealth Interparliamentary Conference, London, 1961. Joint Chairman of Can. Deleg. to 7th Mtg. Can.-U.S. Int. Group, Washington, D.C. Jan. 14-19, 1964. Summoned to Senate Apr. 27, 1963. Speaker, Apr. 27, 1963 to Jan. 6, 1965. Sworn of the Privy Council, Feb. 22, 1966. Party pol.: Lib. Rel.: Catholic. Address: 59 St. Etienne St., Lévis, Que.

CAMERON, HON. DONALD, B.Sc. M.Sc., LL.D. (Banff). B. Mar. 6th, 1903, at Davenport, England. S. of Donald Cameron and Marion MacFayden, both Scottish. Came to Canada, 1906. Ed. at Lakeview High School and Univ. of Alberta. Degrees: B.Sc. 1930, M.Sc. 1934, LL.D. (Honoris Causa) Univ. of B.C. 1959. M. July 6th, 1932, to Stella Mary, dau. of Mr. and Mrs. Samuel Joseph Ewing, of Calgary, Alberta. One daughter: Mary Jean. Professor. Director Dept. of Extension, Univ. of Alberta, 1936-1956; Dir. Banff School of Fine Arts, 1936 to present; Dir. Banff School of Advanced Management, since 1952; Dir. National Film Society of Canada, 1936-1950; Pres. Can. Handicrafts Guild, 1946-49; Mem. National Film Board of Canada, 1943-1950; Chairman Can. Legion Education Services Pacific Command, 1939-46; Mem. National Advisory Comm. on Citizenship, 1939-45; Mem. Can. Institute of Agric.; Amer. Acad. Pol. Science; Mem. Council Can. Assn. for Adult Education; Educational Consultant Performing Arts Magazine. Western Can. Consultant Encyclopedia Britannica; Mem. Can. Govt. Delegation to Ninth Gen. Conf. UNESCO, New Delhi, 1956; Leader Can. Del. UNESCO Conf. Montreal, 1960. Appointed Chairman Royal Commission on Education, Alberta, 1958. Leader Can. Del. Ninth Conf. Commonwealth Parl. Assn. Kuala Lumpur 1963. Dir. Rocky Mt. Life Insurance Co. Summoned to Senate, July 28, 1955. Party pol.: Ind. Liberal. Rel.: United Church. Address: Edmonton, Alberta.

DESRUISSEAUX, HON. PAUL Q.C., L.L.D., (*Wellington*) Lawyer, Editor, Publisher, Broadcaster. B. Sherbrooke, Quebec, Canada, May 1, 1905; S. of Geoffroy François and Sarah (Gauthier) Desruisseaux, grad. St. Charles College, 1928, Montreal College 1931, grad. Law University of Montreal, 1931-34. Post graduate of Batson Institute 1935, Harvard 1935-1936, M. June 16, 1945 to Celine Duchesnes; Children—Louis (deceased), François, Hélèna, Pierre; Admitted to P. of Que. Bar 1934; Practiced in Sherbrooke, Que; Chairman: Radio and Television Sherbrooke Inc., 1967; Quebec Telemedia Ltd., 1967; Melchers Distelleries Ltd., 1967; Honorary Board of Governors of the P. of Q. Association for the Mentally Retarded—1964; Chairman & President: Desmont Research and Development Inc., 1965; Les Publications Sept Jours Inc., 1966; Barwick Printers 1967; President: Cablevision (Montreal) Ltd., 1965; La Tribune Inc., 1955-1967; CHLT-TV, CHLT, CHLT-FM 1955-67; Trilitho Inc., 1964-1967; Cinéma Plaza Lnc., 1965; St. Régis Investments Inc., since 1948; Association Canadienne des Quotidiens de langue française 1961-62; Vice-President: Delta Service Inc., since 1961; Cinéma Télécinéma Inc., since 1954; Cinéma Premier Inc., since 1953; Telegram Printing & Publishing Co., Ltd., since 1951; Director: Royal Bank of Canada since 1962; General Trust of

Canada since 1961; Shawinigan Water & Power Co., 1961 until its nationalization in 1965; Southern Canada Power Co., 1958 until nationalization in 1965; Director. Shawinigan Industries 1962 until nationalization in 1965; Denault Ltd., 1961; Quebec Health Services 1961-65; Laurentian Gas Co., since 1960; Financial Expansion Corp. 1959-65; Quebec General Investments Corp. 1962-63; Walter M. Lowney Co. Ltd. since 1962; Forano Ltd. 1962-65; Société d'Expansion Financière 1962-64; Corgemine Ltd. 1965-67; Director: L'Association Canadienne des Quotidiens de langue Française 1959-62; Canadian Press 1963 to 1967; Canadian Daily Newspaper Association 1963 to 1967; Cartier Gas Co. 1963; Westmount Life Assn. Co. 1964; The Canadian General Electric Co. 1964; Montreal Alouettes Football Club Inc. 1964; Terrebonne Development Co. 1965; University of Sherbrooke Corporation 1959; Commonwealth Press Union 1960-67; Sherbrooke Chamber of Commerce; Vice-President: Board of Trusts University of Sherbrooke 1957; Board of Regents of University of Ottawa 1960-65; Governor, Province of Quebec Chamber of Commerce 1964; Governor, Sherbrooke Hospital 1960; University of Sherbooke 1956; Vice Dean: Faculty of Business Administration University of Sherbrooke, from 1958 to 1964; President: Sherbrooke Section of the Red Cross 1954 to 1957; Ass-Commissioner—Catholic Boy Scouts (Sherbrooke) 1937-39; King's Counsel 1948—Queen's Counsel 1953; Doctor in Law—Honoris Causa, University of Sherbrooke 1964; Commander of the Order of St. Grégoire le Grand 1958; Recipient of the Latin Union, Bene Merenti and French Alliance medals; Member: Club Social, Sherbrooke; Hillcrest; Sherbrooke Country Club; Canadian Club; Quebec Garrison Club; St. James' Club, Montreal; St. George Sherbrooke; St. Denis, Montreal; Forest and Stream Club, Sorel; Summoned to Senate July 8, 1966. Party pol: Lib. Rel: Catholic. Address: 405 Victoria St., Sherbrooke, Que. and 1115 Sherbrooke St. W., Montreal, Que.

GROSART, HON. ALLISTER, H. G. (Pickering). B. Dec. 13, 1906 at Dublin, Ireland. S. of Herbert Montgomery and Elizabeth Mackey, both Irish. Ed. at China Island Mission Schools, Chefoo, North China, 1915-1923; Univ. of Toronto, 1923-1927 Politics and Law and 1928 post graduate International Law. Degrees: B.A., Carnegie Fellow of International Law, 1928. M. July 6, 1944 to Louise Geraldene dau. of Frank George Harnden of Hilton, Ont. Two children: Geraldene Francis and Victoria Elizabeth. Served with Irish Regiment of Can. 2nd Bttn. C.A. (R) with rank of Lt. to Major. Former vice-pres. McKim Advertising Ltd. Toronto and Montreal; former managing dir. Peer International (Canada) and former National Dir. P.C. Assn. of Can. Mem. of Albany (Toronto), Bonaventure (Montreal), Rideau (Ottawa), Royal Can. Geographic Society, Can. Bibliographical Society, Can. Library Assn. and National Press Club (Ottawa). Summoned to Senate Sept. 24, 1962. Party pol. Progressive Conservative. Rel. Anglican Church of Can. Address: The Senate, Ottawa, Ont.

HAYS, HON. HARRY WILLIAM, (Calgary). B. Dec. 25, 1909 at Carstairs, Alta. S. of Dr. Thomas E. Hays and Ambriss Foster. Ed. at Public School, Glenmore and St. Mary's H.S., Calgary. M. Feb. 28, 1934 to Muriel Alica dau. of Ernest Bigland of Calgary. One son: Daniel Phillip. Mayor Calgary 1959-63. Past pres. Can. Swine Breeders Assn. and Southern Alta. Egg and Poultry Producers. Former mem. Alta. Cattle Breeders Assn. and Sheep Breeders Assn. Mem. Calgary Golf and Country Club, Rotary past Dist. Gov. 1963, and Canadian Club. First elected to H. of C. g.e. 1963. Sworn of the Privy Council and apptd. Min. of Agric. April 22, 1963. Summoned to Senate Feb. 24, 1966. Party pol.: Lib. Rel.: Catholic. Address: 8944 Elbow Dr., Calgary, Alta.

KINNEAR, MARY ELIZABETH (*Welland*). B. Apr. 3, 1898 at Wainfleet, Ont. Dau. of Francis Manning, Fr. Can. and Mirelda Ann Carter, Engl. Can. Ed. at Port Colborne P.S. and Welland H.S. M. Dec. 27, 1924 to Robert Alexander (dec. Sept. 14, 1954) son of Louis Kinnear of Port Colborne. Past pres. Victorian Order of Nurses, mem. of Niagara Peninsula Christmas Seals, Red Cross Blood Donors, Port Colborne General Hospital Women's Auxiliary, Business and Professional Women's Club, Ont. Women's Lib. Assn., Women's Lib. Fed. of Can., Port Colborne Country Club and hon. mem. Port Colborne Club and Gyrette Club. Summoned to the Senate April 6, 1967. Party pol.: Lib. Rel.: Anglican. Address: 41 Lakeshore Rd., Port Colborne, Ont.

LAMONTAGNE, HON. MAURICE, P.C. M.Sc. B. Sept. 7, 1917, at Mont-Joli, Que. S. of Alphonse Lamontagne and Sophronie Joncas. Ed. at Rimouski Seminary, Que.; Dominican Coll., Ottawa; Laval Univ. and Harvard Univ. M. in 1943 to Jeannette Morin. Three children: Hélène (Mrs. Lucien Binet), Pierre and Bernard. In 1943, asst. in organizing Faculty of Social Sciences at Laval Univ. and became Prof. of Econs.; Dir. of Dept. of Econs., 1949; apptd. Asst. Deputy Min., Northern Affairs and Nat. Resources, 1954. Econ. Advisor to Privy Council, 1955; resigned in 1957 to become Prof. of Econs. at Ottawa Univ. Apptd. Econ. Advisor to Hon. Lester B. Pearson, then Leader of the Opposition, 1958. Asst. Dean of Faculty of Social Sciences at Ottawa Univ., 1961. Fellow of Royal Society of Can. and Fellow of Royal Society of Arts. First elected to H. of C. g.e. 1963. Sworn of the Privy Council and apptd. Pres. of the Queen's P.C. for Canada 22 April, 1963. Apptd. Secretary of State and Registrar General of Canada February 3, 1964. Professor of Economics at the University of Ottawa since September 1967. Summoned to the Senate April 6, 1967.

LANG, HONOURABLE DANIEL AIKEN, Q.C. (South York); Barrister and Solicitor, Counsel, Lang, Michener, Cranston, Farquharson & Wright—Bank of Montreal Building, 50 King Sreet West, Toronto 1, Ontario; Chairman of the Board, Canada Coal Corporation Limited, President, Standard Trust Company, Member, Board of Governors, University of Toronto, Member, Board of Trustees, Sunnybrook Hospital; Born at Toronto, Ontario, 13 June, 1919, son of Daniel Webster Lang, Q.C., and the late Edna (Aiken) Lang; Educated Upper Canada College; Trinity College University of Toronto, Osgoode Hall Law School 1941 (break for military service) 1945-57; Career—Read law with Lang & Michener; called to the Bar of Ontario, 1947, joined law firm of Lang, Michener & Cranston, Toronto, with same firm to date, summoned to the Senate of Canada, 1964; served in Second World War with the Royal Canadian Naval Volunteer Reserve, 1941-45, discharged with rank of Lieutenant; Liberal, Treasurer Liberal Party in Ontario, 1958-62, Campaign Chairman Ontario, Federal General Elections 1962, 1963, 1965; Councillor, Municipality of Forest Hill, 1957-61; Married Frances Shields, daughter of Dr. H. J. Shields and the late Cecil (Oatman) Shields, 24 September 1948, has two sons, Daniel and two daughters, Nancy, Janet; United Church of Canada, Trustee, Bloor Street United Church Toronto; Knight, Order of St. Lazarus of Jerusalem; Royal Canadian Yacht Club, Toronto Lawyers' (Pres. 1960-61), Badminton and Racquet, Osler Bluff Ski; Residence 43 Hillholm Road, Toronto 7, Ontario.

LEONARD, HONOURABLE THOMAS D'ARCY, C.B.E., Q.C., B.A., LL.D. (Toronto-Rosedale) Born April 29th, 1895, at Toronto, Ont. Son of Charles Joseph Leonard and Eleanor O'Brien, both Can. Ed at University of Toronto and Osgoode Hall. Degrees: B.A., LL.D., (Toronto). Knight Comdr. of the Order of St.

Gregory the Great. Practised law with Jones and Leonard, 1919-34, with Leonard and Leonard, 1934-42. Created Q.C., 1936. General Manager The Canada Permanent Trust Company, 1942-1956. President The Canada Permanent Trust Co., 1951-58; The Continental Life Insurance Company 1955-59; Triarch Corporation Ltd.; The Community Chest of Toronto, 1948; Last Post Fund for Ontario, 1954-58; Canadian Club of Toronto, 1937-38. Vice-Pres. Canada Permanent Mortgage Corporation. Chairman, National War Finance Committee for Ontario, 1943-46. Treasurer Canadian Bar Association, 1948-49. Lieut. 5th Batallion C.E.F. and Royal Air Force. Summoned to Senate, July 28, 1955. Partly pol.: Liberal. Rel.: Catholic. Address: 10 Meredith Crescent, Toronto 5, Ont.

MACKENZIE, HON. NORMAN ARCHIBALD MACRAE, C.M.G., M.M. and Bar, Q.C., B.A., LL.B., LL.M., LL.D., D.C.L., D. Litt., D.Soc.S., F.R.C.S. (University-Point Grey). B. Jan. 5, 1894 at Pugwash, N.S. S. of the Rev. James Arthur MacKenzie and Elizabeth MacRae both Can. Ed. at Pictou Academy, Dalhousie Univ., Harvard, St. John's Coll., Cambridge and Gray's Inn, London. M. Dec. 19, 1928 to Margaret dau. of A. W. Thomas of Toronto. Three children: Patrick Thomas, Susan Elizabeth (Mrs. Trevor Roote) and Sheila Janet. Pres. Emeritus and Hon. Professor of International Law, Univ. of B.C. Dir. Bank of N.S. Mem. Vancouver Comm. Canada Permanent Trust Co. Hon. Colonel. Served with Can. Infantry 1914-19, 6th C.M.R.'s 85th Bn. N.S. Highlanders. Mem. Univ. Advisory Bd., Dept. of Labour; Advisory Comm. on Univ. Trg. for Veterans, Dept. of Veterans' Affairs; Trustee, Carnegie Foundation for Advancement of Teaching, 1951-63 (Chairman of the Board of Trustees, 1959), Teachers' Ins. and Annuity Assn. of America, 1948-63; Pres. National Conf. of Can. Univ., 1946-48, Can. Club of Toronto, 1939-40—Hon. Sec. 1930-1939; Chairman, Research Comm., Can. Inst. of Int. Affairs, 1929-40; Founding Mem. and Hon. Chairman, National Council, Can. Inst. of Int. Affairs; Del. to Inst. of Pacific Relations Conferences—Shanghai, 1931, Banff, 1933, Yosemite, 1936, Virginia Beach, 1939, Mont Tremblant, 1942, Br. Comm. Conf.—Toronto, 1933, Sydney, Australia, 1938, 7th Congress on Laws of Aviation, Lyons, France, 1925, Congresses and Meetings of Univ. of the Br. Comm.—Oxford, 1947, Bristol and Oxford, 1946, Durham and Cambridge, 1953, Melbourne (observer), 1955, London, 1963, Montreal and Toronto, 1959; Hon. Pres., National Fed. of Can. Univ. Students, 1946-47, 1956-57; Mem. Can. Inst. of Public Affairs, Chairman, 1963, American Society of Int. Law, Canadian Bar Assn., Canadian Political Science Assn., Historical Assn., Vancouver Bd. of Trade, Vancouver Can. Club, Legal Survey Committee (Survey of the Legal Profession of Canada), 1949-57; Fellow, Royal Society for the Encouragement of Arts, Manufactures and Commerce, Royal Canadian Geographical Society; Visiting Lecturer, The Univ. of Australia, 1955; Pres., Can. Assn. for Adult Education, 1957-59 and Visiting Lecturer, International Law, U.N.B., Sept.-Dec., 1963. Chairman, Wartime Information Bd., Can., 1943-45, Reconstruction Comm., N.B., 1941-44; Mem. Royal Comm. on National Development in the Arts, Letters and Sciences, 1949-51; Chairman, Conciliation Bds. in Labour Disputes, 1937-42—1966, Victory Loan Comm., Fredericton and York, N.B., 1941-44, Consultative Comm. on Doukhobor Problems, 1950; Pres., Toronto Branch, League of Nations Society, 1932-36; Vice-pres., National Council of Canadian Y.M.C.A.'s: Dir., Can. Council of Christians and Jews, Western Division; Hon. Pres., Save the Children Fund, Canada, B.C. Division, Canadian Mental Health Assn.; Hon. Mem., National Bd. of Dir., Can. Mental Health Assn.; Hon. Pres., U.N. Assn. in Canada, Vancouver Branch; Vice-Pres., U.N. Assn. in Canada; Hon. Pres., Student

Christian Movement, Univ. of B.C. Branch; Vice-Pres., Can. Authors' Assn., National Branch, 1957; Mem., Can. Council, 1957-63; Pres., Can. National Comm. for UNESCO, 1957-60, 1962-63; Mem., Canadian-American Committee, National Planning Association, 1957-63; Pres., Vancouver Branch, English-Speaking Union of the Commonwealth; Chairman, Canadian Del. to the 10th Annual Conf. on UNESCO, Paris, 1958; Pres., Leon and Thea Koerner Foundation, 1955; Dir., Bank of Nova Scotia, 1960; Mem., Vancouver Advisory Bd. of Canada Permanent Toronto General Trust Company, 1962, East African Comm. on Univ. Education, Sept. and Oct., 1962; Chairman, Mt. Allison Conf. on European Common Market, 1962, Priorities Committee, Community Chest and Council, Vancouver, 1962-64, N.S. Univ. Grants Committee, 1963; Mem., P.E.I. Royal Commission on Financing of Higher Education, 1963-64; Dir., Can. Centennial Commission, 1963; Pres., Can. Centenary Council, 1962; Dir. Fathers of Confederation Memorial Foundation, 1963; Mem., N.B. Industrial Development Board, 1965 and Chairman, C.U.F. Comm. On Int. Studies in Canadian Univ., 1963. Mem. Faculty Club, U.B.C., Vancouver, Vancouver Club and Univ. Club, Vancouver. Summoned to Senate Feb. 24, 1966. Party pol.: Ind. Lib. Rel.: United Church. Address: 4509 W. 4th Ave., Vancouver, B.C.

McCutcheon, Hon. M. Wallace, P.C., C.B.E., Q.C., LL.D. Chairman of the Board, The National Life Assurance Company of Canada. Director: Canadian Enterprise Development Corporation Limited; Longmans Canada Limited; Montreal Trust Company; Glens Falls Insurance Company, Glens Falls, New York, Counsel, Shibley, Righton & McCutcheon, Toronto. Born, London, Ontario, May 18, 1906: Son of the late Frederic W. C. McCutcheon and Mary(Vining) McCutcheon. Educated: Oakwood Collegiate Institute, Toronto; Victoria College, the University of Toronto (B.A. 1926); Associate, Society of Actuaries, 1927; Osgoode Hall, Toronto; called to the Bar of Ontario, 1930. Honorary LL.D. St. Francis Xavier University and the University of Western Ontario, 1963. Practiced law with Osler, Hoskin & Harcourt, Toronto, 1930-34. Appointed Assistant to the President, The National Life Assurance Company of Canada, 1934; Secretary 1937; Assistant General Manager, 1938. Served with Wartime Prices and Trade Board 1941-46, latterly as Deputy Chairman of the Board. 1945-62, Vice-President and Managing Director, Argus Corporation Limited and Director and/or Officer of a large number of industrial and financial companies, from which resigned in August, 1962. Summoned to Senate August 9, 1962. Appointed Minister-without-Portfolio, Government of Canada, 1962. Served as Minister of Trade and Commerce, February 11, 1963 to April 22, 1963. Created C.B.E. (Civil) 1946; appointed K.C. (Ontario), 1947. Chairman, The Ontario Cancer Institute and The Princess Margaret Hospital; Member, Advisory Board, St. Michael's Hospital; Member of the Board of Governors, the University of Toronto; Member of the Board, St. Francis Xavier University; Director Canadian-American Committee, and Canadian Trade Committee (Private Planning Association of Canada); Member, Canadian Association of Actuaries; Governor, Canadian Council, International Chamber of Commerce; Member of Senate, Stratford Shakespearean Festival Foundation of Canada; Director, Canadian Society for the Abolition of the Death Penalty; Honorary Vice-President, Canadian Institute of International Affairs; Vice-President and Member Board of Management, Victorian Order of Nurses for Canada; Director, Royal Agricultural Winter Fair; Past President, The Canadian Welfare Council; Past President, Social Planning Council of Metropolitan Toronto;

Past President, Community Chest of Greater Toronto; Trustee, United Community Fund of Metropolitan Toronto. Married Eva Trow Borland, daughter of the late York Borland of Toronto, Dec. 14, 1934; has three sons and two daughters. Clubs: Albany, Granite, National, Rosedale Golf, Tadenac, Toronto Club, University and York (Toronto); London Club (London); Mount Royal (Montreal); Rideau, and Country Club (Ottawa); Vancouver (Vancouver). Society: A.F. and A.M. (Scottish Rite). United Church of Canada. Progressive Conservative. Residence: Ellanvannin Farms, R.R. 1, Gormley, Ontario. Office: 522 University Avenue, Toronto, Canada.

PHILLIPS, HON. DR. ORVILLE HOWARD, (Prince). B. April 5, 1924 at O'Leary, P.E.I. S. of J. S. Phillips and Maud MacArthur, both Can. Ed. at Prince of Wales College and Dalhousie Univ. Doctor of Dental Surgery. M. Aug., 1945 to Marguerite K., dau. of Robert Woodside, of O'Leary, P.E.I. Four children: Brian, Betty, Robert and Patricia. Served R.C.A.F., 1942-45. Mem. Can. Legion, R.C.A.F. Assoc., P.E.I., Curling Assoc., Board of Trade, P.E.I., Dental Assoc. Board of Governors, Prince of Wales University. First elected to H. of C., g.e., 1957. Re-elected at g.e., 1958 and June 1962. Summoned to Senate, Feb. 5, 1963. Party pol.: P.C Rel: United Church, Address: Box 155, Alberton, PE.I. and 195 Grenville St., Summerside, P.E.I.

SULLIVAN, HON. JOSEPH ALBERT, M.D., C.M., (*North York*). B. Jan. 8, 1902, at Toronto, Ont. S. of Edward Sullivan and Essie Taylor, both British. Ed. at Univ. of Toronto Schools; Univ. of Toronto, M.D., C.M., 1926; Post-graduate work in the University of Toronto, New York and several European Centres. Physician and surgeon. Honorary Surgeon to Her Majesty the Queen. Member Can. Jr. Hockey Championship Team 1919, Varsity Grads. Hockey Team (Olympic Champions 1928; Consultant in Otolaryngology to the R.C.A.F., 1942, Chief of Dept. of Otolaryngology, St. Michael's Hospital, Toronto, Ont., 1945; Defence Research Board, Ottawa, 1946; Chief of the Hard of Hearing Clinic & Auditory Research, St. Michael's Hospital, Toronto, Ont., 1950; Mem. of Board of Governors, Univ. of Toronto, 1950; Chief Consultant to the Armed Forces of Canada (Otolaryngology), 1954; Mem. Ont. Cancer Research Foundation, 1954. Mem. of the following Societies: Can. Medical Assoc.; Ont. Medical Assoc.; Academy of Medicine, Toronto; Fellow of Royal Society of Medicine, England; European Collegium; American Otological Society; American Academy of Otolaryngology and Pres. of the American Otosclerosis Study Group. Fellow of the Royal College of Surgeons, Canada; Honorary Fellow of the Canadian Otolaryngological Society; 1963: President, American Otological Society; Honorary Fellow, Otological Section, Royal Society of Medicine. Elected to Honorary Fellowship of Royal Society of Medicine, England, July, 1964. 1968: Elected Senior Member of the Canadian Medical Association. Knight of the Holy Sepulchre, Knight Commander of St. Gregory with Distinction. Clubs: York Club, Granite Club, University Club. Rosedale Golf Club, Seigniory Club, Home Club and Rideau Club. Summoned to Senate, Oct. 12, 1957. Party pol.: P.C. Address: Toronto, Ont.

THOMPSON, ANDREW ERNEST JOSEPH, B.A., M.S.W., (*Dovercourt*). B. December 14, 1924 at Belfast, Ireland. S. of Joseph Stanley and Edith Magill, both Irish. Ed. at Monkton Combe School, England; Oakwood Collegiate, Toronto; Toronto University; Queens University and University of B.C.

Degrees: B.A. (Queens), B.S.W., M.S.W. (U. of B.C.). M. July 26, 1958 to Amy Rusna of Tallinn, Estonia. A social worker. Lt. (R.C.N.-V.R.), 1943-1946. First elected to Ont. Legis. g.e. 1959. Re-elected g.e. 1963. Resigned as Lib. Leader Nov. 16, 1966. Party pol.: Lib. Rel.: Protestant. Address; 1177 Bloor St. W., Toronto, Ont. Summoned to the Senate. April 6, 1967.

YUZYK, HON. PAUL, B.A., M.A., Ph.D., (*Fort Garry*); B. June 24, 1913 at Pinto, Sask. S. of Martin Yuzyk and Katherine Chaban, both Cdn. of Ukrainian descent. Ed. in Saskatoon, Sask.; Bedford Rd. Coll. Coll. Inst.; Saskatoon Normal School and Univ. of Sask. M. July 12, 1941 to Mary dau. of John and Irene Bahniuk of Hafford, Sask.; Four children: Evangeline Paulette, Victoria Irene, Vera Catherine and Theodore Ronald. Prof. of History and Slavic Studies Univ. of Man. 1951-1963; Public teacher, (1933-39), High School Teacher, (1939-42); Served Can. Army, N.C.O., 1943; Awarded Man. Historical Society Fellowship of $2,500 in 1948. In Man. Historical Society held following positions: Secretary-Treasurer (1953-58), chairman of Ethnic Group Studies since 1952, editor of "Transactions" (1953-57), co-editor of "Manitoba Pageant" since 1956, Vice-President (1958-61), President (1961-63), and secretary of the Manitoba Record Society 1960-64; Associate editor of "Opinion", Winnipeg (1948-49); Editorial Associate of "Ukrainian Directory and Year Book" (1952-56); Founder and first Sect'y-Treas. (1954-56) of the Cdn. Assn. of Slavists; Pres. of Ukrainian Cultural and Educational Centre since 1953; Mem. of General Curriculum Comm., Dept. of Education of Manitoba (1958-59), Y.W.C.A. Advisory Comm. on Adult Education in Winnipeg (1958-63); Author "The Ukrainians in Manitoba: A Social History" (Univ. Toronto Press, 1953); Co-author of "Ukrainian Reader" (1960), textbook prescribed for High Schools in Manitoba, Sask. and Alta.; Author of "Ukrainian Canadians: Their Place and Role in Canadian Life" (Toronto, 1967); also "Canadiens Ukrainiens: Leur Place et leur rôle dans la vie canadienne" (Winnipeg, 1967); Pres. Can. Assn. Slavists, 1963-64; Vice-Pres. Ukrainian Can. Foundation of Taras Shevchenko since 1964. Mem. Bd. Dir. Cdn. Centenary Council. Dir. Can. Council of Christians and Jews (Western Region) since 1963; Social Service Audit, Inc. (Man.) since 1964 and Community Welfare Planning Council (Winnipeg) since 1965. Pres. and Dir. Higher Education Scholarship Foundation (Toronto) since 1966. Mem. Cdn. Del. to 18th Gen. Assem. U.N., 1963. Summoned to Senate Feb. 4, 1963. Party pol.: P.C.; Rel.: Ukrainian Catholic. Address: 1122 Hector Bay E., Winnipeg 9, Manitoba.

DIRECTORS OF RESEARCH

PAQUET, GILLES, born in Quebec City in 1936, has done undergraduate work in philosophy and social sciences at Laval University, and graduate work in economics at Laval and Queen's University under fellowships from the Quebec government and the Canada Council. Has lectured in economics at Carleton University since 1963 and is presently an associate professor at Carleton, has conducted research on migration movements, social security, economic development, and urban economics under grants from diverse organizations including the Canadian Council on Urban and Regional Research and the Central Mortgage and Housing Corporation; has published a number of papers on these subjects. Has been associated with the work of the Special Committee of the Senate on Aging, of the Comité de Recherches sur l'Assurance-Santé (Quebec), and is presently a director of La Société Canadienne de Science Economique and the secretary-treasurer of the Canadian Economics Association.

Pocock, Philip John, born in London, Ontario, 19 February 1925. Educated London primary schools; Greygables School Welland, Ontario. Attended the University of Western Ontario; transferred to the Massachusetts Institute of Technology to take a B.Sc. in Aeronautical Engineering. Joined the National Research Council in 1946 and conducted research in the field of fluid mechanics, industrial aerodynamics, the aerodynamic design of aircraft and missiles. On leave from NRC, investigated the design of new aircraft types in the Aero Projects Section of the Royal Aircraft Establishment, England. While at NRC served for some time as Secretary of the Technical Advisory Panel of the National Aeronautical Research Committee and was a Canadian Co-ordinator for the Commonwealth Advisory Aeronautical Research Council. Was appointed Head, Low-Speed Aerodynamics. Laboratory in 1960. Joined EXPO '67 in 1964 where duties included that of Project Officer for the initial planning of the International Exhibition of Industrial Design and Project Officer of the International Exhibition of Photography. Principle extra-curricular activity is concerned with visual communication. In this field he was joint Chairman of an international symposium "Photography and Modern Consciousness" (1967); He is joint author of the book "The Autobiography of J. M. Synge" (O.U.P.).

WITNESSES

Blackett, Patrick Maynard Stuart, C.H. 1965; F.R.S. 1933; M.S.; Professor Emeritus and Senior Research Fellow, Imperial Coll., since 1965; Dep. Chm. and Scientific Adviser (part-time), Advis. Council on Technology, Ministry of Technology, since Nov. 1964 (on leave of absence from Imperial College); President of the Royal Society since 1965 (Member of Council, 1963); b. 18 Nov. 1897; s. of Arthur Stuart Blackett; m. 1924, Costanza Bayon; one s. one d. *Education:* R.N. Colleges, Osborne and Dartmouth; Magdalene College, Cambridge. Served with R.N., 1914-19; Fellow of King's College, 1923-33, Hon. Fellow, 1949; Prof. of Physics, Birkbeck College, 1933-37; Langworthy Professor of Physics, University of Manchester, 1937-53. Royal Medal of Royal Society, 1940. Hon. D.Sc.: New Delhi, Strasbourg, 1947; Reading, 1948; Q.U.B., 1953; Leeds, Durham, Manchester, 1962; Oxon., 1963; Exeter, Bristol, York, Hull, Sussex, 1966; Hon. Sc.D., Cantab., 1954; Hon. LL.D.: Glasgow, 1955; Dalhousie (Halifax), 1960; St. And., 1962. Hon. Fellow: Magdalene Coll., Cambridge, 1948; Manchester Coll. of Technology, 1966; Indian Academy of Sciences, 1949; Member, Berlin Academy of Science, 1950; Hon. Fellow Weizmann Institute of Science (Israel), 1954. Corr. Member Academy of Sciences, Institute of France; Hon. Fellow, Institute of Physics, 1962; For. Associate, Nat. Acad. of Sciences, Washington, 1966; For. Mem., Accademia Nazionale dei Lincei, Rome, 1965; Mem., Soviet Academy of Sciences, 1966. Pro-vice-chancellor of Manchester Univ., 1950-52; Dean of Roy. Coll. of Science (Imperial Coll.), 1955-60; Pro-Rector of Imperial Coll. of Science and Technology, 1961-64; Professor of Physics, Imperial Coll. of Science and Technology, London Univ., 1953-65; Mem. Scientific Policy Committee of European Organisation for Nuclear Research, 1954-58; Mem. Bd. of Nat. Research Development Corp., 1949-; Mem. Governing Bd. of Nat. Inst. for Research in Nuclear Science, 1957-60; Mem. Council of Dept. of Scientific and Industrial Research, 1955-60; Mem. Council for Scientific Policy, 1965-. Chairman Research Grants Cttee., Dept. of Scientific and Industrial Research, 1956-60; Pres. Brit. Assoc. for the Advancement of Science, 1957-58; Member Council, Overseas Development Institute, 1960-. Trustee, British Museum, 1963-65. American Medal for Merit, 1946; Nobel Prize for Physics, 1948; Copley Medal of Roy. Soc., 1956.

Publications: Scientific papers on nuclear and atomic physics, cosmic rays and rock magnetism; Rayons Cosmiques, 1934; Military and Political Consequences of Atomic Energy, 1948; Lectures on Rock Magnetism, 1956; Atomic Weapons and East-West Relations, 1956; Studies of War, 1962. *Address:* Ministry of Technology, Millbank Tower, Millbank, S.W.1; Imperial College of Science and Technology, S.W.7.

BLADEN, VINCENT WHEELER, M.A. (Oxon) LL.D. (University of Western Ontario and Carleton University D.Litt. (Acadia) F.R.S.C. Born, 1900, England. Educated Newcastle High School and Rolliol College, Oxford. On the staff of the Department of Political Economy in the University of Toronto since 1921. Full professor since 1940. Administrative appointments in the University of Toronto: Director of Institute of Industrial Relations, 1946-50, Director of Institute of Business Administration, 1950-53, Chairman of Department of Political Economy, 1953-58, Dean of the Faculty of Arts and Sciences, 1958-66. Edited Canadian Journal of Economics and Political Science, 1935-47. Have been President of the Canadian Political Science Association (1948) and of Section II of the Royal Society of Canada. Royal Commissioner to inquire into the Automotive Industry of Canada. Chairman of the A.U.C.C. (Association of Universities and Colleges of Canada) Commission on the Financing of Higher Education. Chairman of the Adjusted Assistance Board, 1965. Author of Introduction to Political Economy and of more than 100 scholarly papers.

BOUCHER, JEAN. Born in Quebec City, May 9, 1919. Educated at Garnier College (Quebec): B.A. 1939. Laval University (Quebec): Law (LL.L. 1942), Social Sciences (L.Sc.Soc. 1944); Quebec Bar 1943. Chicago University: Fellow of the Department of Political Science; post-graduate studies in public administration (1944-1946). 1946-1950, Laval University—Lecturer in Policial Science. 1950-1963, Department of Citizenship and Immigration, Ottawa. 1950-1957—Assistant to Deputy Minister and Director of Administrative Services. 1957-1963—Director of Citizenship. 1963-1965, Commissioner, Civil Service Commission of Canada. April 1965, Director, Canada Council. Head or alternate head of Canadian delegations at several international conferences of the International Refugee Organization, the Intergovernmental Committee for European Migration, U.N. Economic and Social Council, the U.N. Conference on Statelessness and the U.N. Commission on Human Rights. Member of the Council of the North West Territories (1953-1957). Charter Member of the Institut Canadien des Affaires Publiques, the Ottawa Chapter of the Canadian Political Science Association, and the Cercle Universitaire of Ottawa. Board member of various scientific and educational organizations, such as the Canadian Social Science Research Council, the Institut Canadien d'Education des Adultes, the Canadian Institute of Public Affairs, the Overseas Institute, the Welfare Council of Ottawa and the Ottawa United Appeal. Mr. Boucher is married and has two children, a son and daughter.

BROWN, G. MALCOLM. Born in Compbellford, Ontario, July 16, 1916. Education: M.D., C.M., Queen's University, 1938, Rhodes Scholarship 1938, D. Phil., Oxon, 1940, Research Scholar, Radcliffe Infirmary, 1941-43. Higher Professional Qualifications: M.R.C.P. (London), 1943; F.R.C.P.(C), 1946; F.A.C.P., 1949; F.R.C.P. (London), 1961; F.R.S.C., 1966. Military Service: R.C.A.M.C., England and Northwest Europe 1943-46. University Appointments: Queen's University: Associate Professor of Medicine, 1946-51, Professor of Medicine, 1951-65, Member of Senate, 1949-52, Member of University Council, 1949-52, Member of Board of Trustees, 1966. University of Ottawa: Professor of Medicine, 1965.

Hospital Appointments: Kingston General Hospital: Attending Physician, 1946-65; Director, Clinical Investigation Unit, 1961-65; Kingston Military Hospital: Consulting Physician, 1946-65; Department of Veterans Affairs, Kingston District: Chief of Service—Medicine, 1946-65; Ottawa General Hospital: Attending Physician, 1965; Ottawa Civic Hospital: Consulting Physician, 1965. Scientific and Professional Societies: College of Physicians and Surgeons of Ontario, Member of Council 1949-58, President 1956-58; Royal College of Physicians and Surgeons of Canada, Member of Council 1954-58 and 1960-66, Member of Executive 1956-58, 1964-66, President 1962-64; American College of Physicians, Regent 1965; Canadian Foundation for the Advancement of Therapeutics, Director 1963; National Cancer Institute of Canada, Representative Member 1965; Ontario Cancer Treatment and Research Foundation, Member, Advisory Medical Board 1966; Muskoka Hospital Memorial Research Fund, Chairman, Research Committee 1965; Member, Advisory Panel of the CIBA Foundation, London, England, 1966; Fellow, Royal Society of Canada. Member: American Society for Clinical Investigation, American Federation for Clinical Research, American Society of Hematology, Canadian Association of Gastroenterology, Canadian Physiological Society, Canadian Society for Clinical Investigation, Ontario Medical Association, Canadian Medical Association, International Society of Hematology, American Clinical and Climatological Society. Government Agencies: Defence Research Board, Panel on Arctic Medical Research, Member 1947-54, Chairman 1952-54; Defence Research Board, Panel on Nutrition, Member 1952-58; Defence Research Board, Defence Medical Research Coordinating Committee, Member 1967; Department of National Health and Welfare, Canadian Council on Nutrition, Member 1950-54; National Research Council, Member 1965; Medical Research Council 1960, Member of Executive 1961, Chairman 1965; Science Council of Canada, Member 1966. Publications: Seventy-odd papers in scientific journals in the fields of malaria research, cold physiology, hematology and gastro-enterology.

CORRY, JAMES ALEXANDER. Political Scientists, Principal, Queen's University. Dr. Corry was born in Billbank, Ontario, November 29, 1899. He was Rhodes Scholar for Saskatchewan in 1924. He holds degrees from the University of Saskatchewan (LL.B.); Oxford (B.C.L.); Columbia (LL.M.); University of Saskatchewan (LL.D.). His activities are listed as follows in *WHO'S WHO*: Called to the Bar of Saskatchewan 1930. Professor of Law, University of Saskatchewan, 1927. Hardy Professor of Political Science, Queen's University, 1936-61. Vice-Principal, Queen's University, 1951-61. Principal, Queen's University, 1961-. Dr. Corry is well known throughout the English-speaking world for his textbook *Democratic Government and Politics* (1946). He is also the author of *Elements of Democratic Government* (1947); *Law and Policy* (1959); and *The Changing Conditions of Politics* (1963). From time to time he has been called upon to advise the federal government on Dominion-Provincial relations and he was a contributor to the Rowell-Sirois commission. He has been a member and a former chairman of the Social Science Research Council of Canada, a member of the council for the survey of the legal profession in Canada, and of the Canadian Broadcasting Corporation Board of Governors. In 1957 he was mainly responsible for the launching of the Queen's Faculty of Law, and he was its acting dean for the first year. Dr. Corry in 1960 received a Special Senior Award of the Canada Council (the $8,000 awards which preceded the Canada Council Medals) for special study of the development of individualism in the Western world and the type of character and mentality generated by large-scale organizations and institutions.

DRURY, HON. CHARLES MILLS, P.C., C.B.E., D.S.O., Q.C. (Saint-Antoine-Westmount). B. May 17, 1912 at Westmount, Que. S. of Victor Montague and Pansy Mills both Can. Ed. at Bishop's Coll. Lennoxville Royal Military Coll., McGill Univ. and post-graduate studies Paris Univ., France. Degree: Bachelor of Civil Law. M. Sept. 12, 1939 to Jane Ferrier, dau. of John Counsell of Hamilton, Ont. Four children: Diana, Leith, Victor Montague and Charles Gibbons. Former Dir. Avis Transport of Can., Needco Frigistors Ltd., Alaska Yukon Refiners Ltd. and Western International Thermal Powers Ltd. Chief UNRRA mission to Poland, Warsaw, 1945-47; Economic Div. Dept. of External Affairs 1947-49; Dep. Min. Dept. National Defence 1949-55; past pres. U.N. Assn. in Can.; pres. Montreal Bd. of Trade 1961-62; past pres. Can. Centenary Council; past chairman Montreal Br. Can. Inst. International Affairs and past mem. of Northwest Territories Council. Clubs: St. James, Montreal; Cercle Universitaire, Montreal and Quebec Reform, Montreal. First elected to H. of C. g.e. 1962. Re-elected g.e. 1963 and 1965. Sworn of the Privy Council and apptd. Min. of Defence Production April 22, 1963 and Min. of Industry July 25, 1963. Party pol.: Lib. Rel.: Protestant. Address: 400 Kensington Ave., Westmount, Que.

FLYNN, HENRY. *Born:* Toronto, Canada, 9 March 1917. EDUCATION: La Salle Extension University, Business Management 1942; University of Toronto, BASc Electrical Engineering 1949; University of Toronto, MASc Electronic Engineering 1951. *Societies*: Registered Professional Engineer, Province of Ontario; Fellow, British Interplanetary Society, Canadian Club. *June 1967 to present*: Science Secretariat, Privy Council; Science Adviser; Member of Government Task Force on Satellites. *1960-1967:* International Communications; Satellite and Space Communications; Military satellite communication systems; Radio spectrum utilization and frequency planning for space programmes; Direct broadcasting from satellites for home reception; Coordination of communication experiments for manned space-mission vehicles. *1951-1960:* Defence Research Board; Telecommunications Staff Officer; Defence Science Liaison Officer, Canadian Joint Staff, Washington; Consultant to Joint Intelligence Committee; Scientific Advisory Staff Functions. *1942-1945:* Royal Canadian Air Force. Address: 2269 Whitehaven Crescent, Ottawa, Ontario.

GAUDRY, ROGER, D.Sc., F.R.S.C. First lay rector of the University of Montreal, Dr. Gaudry was born in Quebec in 1913 and educated at the Pensionnat St-Louis de Gonzague and the Petit Séminaire de Québec where he obtained the Bachelor of Arts degree of Laval University in 1933 and the Governor-General's Medal. In 1937 he received the degree of Bachelor of Applied Sciences from Laval University. For three consecutive years he was awarded the Price bursary for being first in class. Appointed Rhodes scholar in 1937, he spent two years in research at Oxford University. He received the Doctor of Science degree from Laval in 1940, became Associate Professor of Chemistry in 1945 and, in 1950, a full Professor in the Faculty of Medicine. In 1954 he was named deputy director of research laboratories of Ayerst, McKenna and Harrison, drug manufacturers, in Montreal which were to become one of the most important industrial research centres in Canada. He became director of the laboratories in 1957 and vice-president in 1963, continuing to direct research until his nomination as Rector of the University of Montreal in June 1965. During his scientific and professional career Dr. Gaudry received numerous distinctions. He was three times named as laureate of the scientific Prize of the Province of Quebec. In 1958 he was awarded the Léo Pariseau Medal of the French Canadian Association for the Advancement of Science. In 1954 he became a Fellow of the Royal Society of Canada, and a lecturer at the Institut scientifique franco-canadien at the University of Paris. He was President of the Canadian Institute of Chemistry in 1955-56 and of the Canadian Association of Rhodes Scholars in 1960-61. He became a member of the Council of the Society of Industrial Chemistry of France in 1960. In 1962 he became a member of the Defence Research Board and of the Governing Board of the National Cancer Institute. In 1963 he was named member of the National Research Council. The Corporation of Professional Chemists of Quebec named him honorary life member in 1964 and he became an honorary member of the Society of Industrial Chemistry of France in April 1965. In October 1965 he received the medal of the "Anciens de l'Université Laval". Dr. Gaudry is the author or co-author of about 90 scientific papers dealing mainly with organic and biological chemistry.

JACKSON, RAY WELDON. Born 11 November 1921, Toronto. Education: B.A. Sc., University of Toronto (Engineering Physics) 1944. Ph.D., McGill (Nuclear Physics) 1950; American Council of Learned Societies Advanced Graduate Fellow, Yale (Philosophy of Science) 1951-52. Employment: Royal Canadian Navy 1943-46, Radar Officer on loan to Royal Navy. Yale University, Defence contract research 1952-54. Sprague Electric Company, Massachusetts, industrial research on semiconductors, 1954-56. RCA Victor Co., Montreal, industrial research on electronic systems and semiconductor devices (Director of Semiconductor Laboratory) 1956-64. Sabbatical as Visiting Professor, Solid State Physics, McMaster University 1964-65. Associate Research Director, Program Development, RCA Victor Co., 1965-66. Appointed Science Adviser to the Science Secretariat January 1966.

KILLIAN, JAMES RHYNE, JR. Chairman of the Corporation, Massachusetts Institute of Technology. Dr. James R. Killian, Jr., became Chairman of the Corporation of the Massachusetts Institute of Technology on January 1, 1959, after nearly ten years as President. The period of his presidency was marked by great expansion and building, by increases in graduate study and in research, and by a strengthening of the humanities and social sciences. For a number of years Dr. Killian has been one of the leading spokesmen for educational innovation and curriculum reform, especially in pre-college schools for the strengthening and broadening of engineering education; and for greater support of basic research. He has also strongly supported bringing new quality and modern methods into humanities education along with new quality in science education. From November, 1957, to July, 1959, Dr. Killian was on leave from M.I.T., serving as Special Assistant for Science and Technology to President Eisenhower. This was the first time a President of the United States had appointed a Science Adviser, and in this position Dr. Killian chaired the President's Science Advisory Committee, which was reconstituted to report directly to the President. This pioneering arrangement in the White House, which has been continued and extended by Presidents Kennedy and Johnson, was used by President Eisenhower to assist him in developing a space program and organization, in strengthening U.S. military technology, in initiating new studies and negotiations looking toward limitation of nuclear tests, and in clarifying and strengthening the Federal Government's policies, programs, and organization for science and technology. As the President's Science Adviser, Dr. Killian assisted in reassuring the American public about our scientific and technological strength following Sputnik I. Earlier (1954), President Eisenhower had asked Dr. Killian to head a special task force of about forty scientists, engineers, and military officers, the Technological Capabilities Panel, which made important recommendations to the President and the National Security Council for advancing our military technology, especially our missiles program. Dr. Killian was born in Blacksburg, S.C., on July 24, 1904, the son of the late James Robert and Jeannette (Rhyne) Killian and a descendant of Andreas Killian, who came from Germany to Pennsylvania and in 1749 emigrated to Catawba County, N.C. His father was a textile manufacturer. After attending the McCallie School in Chattanooga, Tenn., he studied at Trinity College (now Duke University) from 1921 to 1923, when he transferred to M.I.T. He was a member of the Class of 1926 and received the degree of Bachelor of Science in business and engineering administration. He remained at the Institute to become assistant managing editor of "The Technology Review". He became managing editor in 1927 and served as editor from 1930 to 1939, when he was made executive assistant to the President of M.I.T., Dr. Karl Taylor Compton. During World War II, when Dr. Compton was one of the nation's leaders in the application of science to the war effort, and when M.I.T. was transformed into one of the nation's largest centers for weapons research and development, Dr. Killian carried the burden of administering the Institute's educational affairs. He was appointed executive vice president in July, 1943, and was elected vice president and member of the Corporation in December, 1945. At the age of 45, in April, 1949, Dr. Killian became President and Dr. Compton became Chairman of the Corporation. His inauguration as President in 1949 was the concluding event in M.I.T.'s great Mid-Century Convocation, "The Social Implications of Scientific Progress", in which some of the world's most distinguished figures participated, led by Sir Winston Churchill. Under Dr. Killian's Presidency and chairmanship, M.I.T. has steadily increased its financial resources, not only to meet current needs but also, through long-range plans, to provide for continual advancement in education and research. Seventy per cent of M.I.T.'s present invested funds have come through gifts and growth since 1950. Early in his administration, the Institute, in response to a recommendation of a Faculty Committee on Educational Survey formed at his suggestion, established a School of Humanities and Social Studies. The Institute program was further widened when, in 1952, a School of Industrial Management was established through grants from the Alfred P. Sloan Foundation, Inc. The Center for International Studies and Lincoln Laboratory are other important units of M.I.T. established during Dr. Killian's presidency. These extensions of the M.I.T. program were all contributory to the creation of a new kind of institution which Dr. Killian has described as a "university polarized around science". Dr. Killian has an extensive record of service to the government. He served from 1956 to 1957 and from 1959 to 1961 as chairman of the board of trustees and he continues as a trustee of the Institute for Defense Analyses, an organization founded under his leadership by M.I.T. and other universities for applying scientific methods and analysis to military problems. He was a member of the Science Advisory Committee of the Office of Defense Mobilization appointed by President Truman in 1951, and when this committee became the President's Science Advisory Committee late in 1957, Dr. Killian became its chairman and served in that post until July, 1959. In 1961, President Kennedy appointed him consultant-at-large to the committee. He was a member of the President's Communications Policy Board, 1950-51; the President's Advisory Committee on Management, 1950-52; the

Board of Visitors of the U.S. Naval Academy, 1953-55; and was chairman of the Army Scientific Advisory Panel from 1951-56. Dr. Killian retired in 1963 as Chairman of the President's Foreign Intelligence Advisory Board after two years of service. During the Eisenhower administration he served as chairman of the first such board. In addition to Dr. Killian's participation in government advisory and study groups, he has been a member of commissions and groups studying national problems. In 1954-56 he was a member of the Committee for the White House Conference on Education. In 1960-61 he served on the President's Commission on National Goals, which prepared the report, "Goals for Americans". He was also a member of the Rockefeller Brothers Panel which had the overall responsibility for a series of six Special Studies issued during the period 1958-1961 and published under the general title, "Prospect for America". In 1962, at the request of President Kennedy, the National Academy of Sciences appointed a committee to make a report on the utilization of scientific and engineering manpower, and Dr. Killian chaired this group. In 1965 he was invited by the Carnegie Corporation to be Chairman of the Carnegie Commission on Educational Television, a commission which in 1967 made recommendations for extensive development of "public television". In March, 1968, Dr. Killian was nominated by the President and confirmed by the Senate as a Director of the Corporation for Public Broadcasting for a six-year term. Dr. Killian was a director of the Federal Reserve Bank of Boston from 1954-57. He is a trustee of the Alfred P. Sloan Foundation, the U.S. Churchill Foundation, Washington University, Mount Holyoke College, Boston Museum of Fine Arts, the Boston Museum of Science, the Mitre Corporation, and the Nutrition Foundation. He is a member of the board of American Telephone and Telegraph Company, the Cabot Corporation, General Motors Corporation, and the Polaroid Corporation. From 1955 to 1958 he served as President of Atoms for Peace Awards, Inc., and he was elected to this office again in 1959. He was Moderator of the American Unitarian Association from 1960-61. His honorary degrees include: LL.D., Union College, 1947; Bowdoin College, 1949; Northeastern University, 1959; Duke University, 1959; Boston University, 1950; Harvard University, 1950; Williams College, 1951; Lehigh University, 1951; University of Pennsylvania, 1951, University of Chattanooga, 1954; Tufts University, 1955; University of California, 1956; Amherst College, 1956; College of William and Mary, 1957; Brandeis University, 1958; New York University and Johns Hopkins, 1959; Providence College, 1960; Temple University, 1960; University of South Carolina, 1961; Meadville Theological School, 1962; Sc.D., Middlebury College, 1945; Bates College, 1950; University of Havana, Cuba, 1953; Notre Dame University, 1954; Lowell Technological Institute, 1954; Columbia University, 1958; College of Wooster, 1958; Oberlin College, 1958; University of Akron, 1959; Worcester Polytechnic Institute, 1960; University of Maine, 1963; D.Eng., Drexel Institute of Technology, 1948; University of Illinois, 1960; University of Massachusetts, 1961; D.Appl. Sci., University of Montreal, 1958; Ed.D., Rhode Island College, 1962; HH.D., Rollins College, 1964. Dr. Killian received the President's Certificate of Merit in 1948; the Certificate of Appreciation, Department of the Army, 1953; and the Decoration for Exceptional Civilian Service, Department of the Army, 1957; the Public Welfare Medal of the National Academy of Sciences, 1957; Officer, French Legion of Honor, 1957; the Gold Medal of the National Institute of Social Sciences, 1958; World Brotherhood Award of the National Conference of Christians and Jews, 1958; Award of Merit of the American Institute of Consulting Engineers, 1958; Washington Award, Western Society of Engineers, 1959; Distinguished Achievement Award, Holland Society of New York, 1959; the Gold Medal of the International Benjamin Franklin Society, 1960; the Good Government Award, Crosscup-Pishon Post, American Legion, 1960; and the Hoover Medal, 1963. He was elected honorary member of the American Society for Engineering Education in 1963. A fellow of the American Academy of Arts and Sciences, Dr. Killian is also a member of Sigma Chi and an honorary member of Phi Beta Kappa and Tau Beta Pi. His clubs include the Metropolitan (Washington), the Club of Odd Volumes, St. Botolph, Union, and Algonquin (Boston), the Century (New York City) and the University Club of New York City. Dr. Killian was married in 1929 to Miss Elizabeth Parks of Asheboro, N.C., a graduate of Wellesley College. They have one daughter, Carolyn (Mrs. Paul R. Staley), and a son, Rhyne Meredith Killian.

King, Alexander, Dr. (C.B.E.)—Age: 59. Studied chemistry at the Imperial College of Science, London, and the University of Munich. Demonstrator and later Senior Lecturer, Imperial College, (until 1941). Harrison Prize, Chemical Society (1939). 1939 Leader, Imperial College Expedition to Jan Mayen. 1941-1942 Deputy Scientific Adviser, Minister of Production. 1943-1947 Head of the United Kingdom Scientific Mission, Washington, and Scientific Attaché, British Ambassy, Washington. 1947-1950 Head of the Scientific Secretariat, Lord President of the Council, London and Secretary, Advisory Council on Scientific Policy. 1948-1951 Honorary Secretary, Chemical Society of London. 1950-1957 Chief Scientist in charge of Intelligence and Overseas Divisions, Department of Scientific and Industrial Research, London. 1951-1957 Chairman, Productivity and Applied Research Committee of the Organization for European Co-operation. 1954-1962 President of the International Federation of Documentation, The Hague. 1957-1961 Deputy Director of the European Productivity Agency of the Organization for European Economic Co-operation. 1958-1961 Director, O.E.E.C. Office of Scientific and Technical Personnel. 1961 Director for Scientific Affairs, O.E.C.D.

Leblanc, Napoléon. Obtained his Bachelor of Agronomy in 1942 from the Faculty of Agriculture, Laval University. In 1941 he received his Master's Degree in Social Sciences (sociology) from Laval's Faculty of Social Sciences. He has been a professor on that Faculty since 1960, and Dean of the Faculty since 1961. Dean LeBlanc has been President of the National University Labour Committee since 1956. In this capacity he has published a work entitled *Report on Labour Education Programs in Canadian Universities* (1959). He participated in a sociological survey of the diocese of St. Jerome, from May 1957 to June 1959. Dean LeBlanc is a member of the Canadian Institute of Public Administration; the Canadian Association of French-speaking Anthropologists, Social Psychologists and Sociologists; the Canadian Council on Urban and Regional Research, and the Study Committee for Adult Education, Quebec Department of Youth (1962-63).

Dr. LeClair, J. Maurice. Vice-Dean of Medicine and Professor and Chairman, Department of Medicine, University of Sherbrooke; Born in Sayabec, Quebec, 1927. Education: B.Sc., McGill University 1947, M.D., C.M., McGill University 1951, M.Sc., University of Minnesota 1958. Higher Professional Qualifications: F.R.C.P.(C); F.A.C.P., C.S.P.O. Hospital Appointments: Hospital Notre-Dame, Montreal, Attending Physician 1958-65. University Appointments: University of Montreal, Associate Professor of Medicine, 1962-64; University of Sherbrooke, Professor and Chairman, Dept. of Medicine, 1965, Vice-Dean of Medicine, 1967. Scientific and Professional Societies: Royal College of Physicians and Surgeons of Canada, Co-chairman, Committee on Credentials; Association of Internists of Province of Quebec, Secretary 1962-65; National Cancer Institute of Canada, Member, Board of Directors; Member: Alpha Omega Alpha Society, Canadian Medical Association, Association de Médecins de la Langue française, Société médicale de Montréal, Association of Professors of Medicine, Montreal Medical-Chirurgical Society, American College of Physicians, Club de Recherche clinique de Québec, American Association for the Advancement of Science, New York Academy of Science. Government Agencies: Medical Research Council, Member 1967, Chairman, Grants Committee for Clinical Investigation 1968. Publications: Sixteen papers in scientific journals in the fields of internal medicine and haematology.

MACKENZIE, C. J., C.M.G., M.C., F.R.S., Chalmers Jack Mackenzie was born in St. Stephen, N.B. and received his B.E. from Dalhousie in 1909 and his M.C.E. from Harvard in 1915. He began his professional career in the Maritimes, but as early as 1910 he had moved West where he engaged in professional engineering. From 1916 to 1918 he was overseas with the 54th Battalion, C.E.F., and was awarded the Military Cross. In 1918 he returned to the University of Saskatchewan as Professor of Civil Engineering, and from 1919 to 1939 carried on a great variety of activities, including his university work and a consulting practice. In 1921 he was appointed Dean of the Engineering College at Saskatoon. In 1935 he was appointed to the Advisory Council of the National Research Council, and in 1939 was made Acting President when General McNaughton was given charge of the Canadian Active Service Force overseas. In 1944 he was made President. He was President of the Atomic Energy Control Board 1948-61. In 1952 he resigned from the Presidency of the National Research Council to become President of the newly-formed Crown Company, Atomic Energy of Canada Limited. He retired from this position in 1953. He was President of the Association of Canadian Clubs 1958-62. Dr. Mackenzie has held many public offices and among his honours and awards are: M.C. in 1918, C.M.G. in 1943, Medal for Merit (U.S.) in 1946, Cross of the Legion of Honour (France) in 1947, Kelvin Medal in 1953, R. B. Bennett Empire Prize in 1954. He has received honorary degrees from 18 universities. *Fellowship in Royal Societies:*— F.R.S.C., 1941; F.R.S., 1946; F.R.C.P. (C) Hon., 1947; F.R.C.S. (C) Hon., 1947. *Professional Awards:* Engineering Institute of Canada, Plummer Medal in 1927; Engineering Institute of Canada, Sir John Kennedy Medal in 1943; Chemical Institute of Canada, Montreal Medal in 1963. *Honorary Memberships:* Engineering Institute of Canada, 1947; American Society of Civil Engineers, 1952; Professional Institute of the Public Service of Canada, 1954; The Association of Consulting Engineers of Canada, 1960. *Current Activities:* Chancellor, Carleton University, 1954; Member, Advisory Council, National Research Council, 1935; Member, Canada Council, 1963; Director, Canadian Chemical Company Limited, 1954; Director, Columbia Cellulose Company Limited 1954; Member, Ottawa Advisory Committee, Canada Permanent Trust Co. 1960. Appointed member of the Canada Council, July, 1963. Honoured in first list of the Order of Canada, July, 1967.

MCCARTER, J. ALEC. Professor of Biochemistry and Director Cancer Research Laboratory, University of Western Ontario. Born in England, 1918. Education: B.A., Honours Chemistry, University of British Columbia, 1939; M.A., Chemistry and Bacteriology, University of British Columbia, 1941; Ph.D., Biochemistry, University of Toronto, 1945. Higher Professional Qualifications: F.R.S.C., 1964. Appointments: Research Officer, National Research Council Atomic Energy Project, 1945-48; Dalhousie University: Associate

Professor of Biochemistry, 1948-50, Professor and Head, Department of Biochemistry 1950-65; University of Western Ontario: Professor of Biochemistry and Director, Cancer Research Laboratory, 1965. Graduate Experience: British Empire Cancer Campaign Exchange Fellow 1960. Scientific and Professional Societies: Canadian Biochemical Society, Past President 1967, Biochemical Society, Member, New York Academy of Sciences, Member, Fellow, Royal Society of Canada, Member, Research Advisory Group of National Cancer Institute, 1967. Government Agencies: Medical Research Council: Member 1962-68, Member of Executive 1964-66, Chairman, Fellowships Committee 1964-66, Chairman, Grants Committee for Cancer, Growth and Differentiation 1967; National Research Council: Member, Associate Committee on Biophysics. Publications: Approximately 30 papers in scientific journals in the field of biochemistry and cancer research.

MILLIGAN, FRANK A. Previously assistant secretary to the Cabinet since 1963 and a former research director of the Royal Commission on Government Organization (Glassco Commission), joined the staff of the Canada Council as assistant director in December, 1966. He is in charge of the Council's programme of assistance to research in the humanities and social sciences, a post created because of the substantial expansion of the Council's activities in these fields. Born in Halifax in 1921, Mr. Milligan holds an M.A. in history and political science from the University of Manitoba. After serving in the Canadian army during World War II, he lectured in political science at the University of Manitoba (1947-48), then studied for two years at the London School of Economics under a Beaver Club scholarship. On his return to Canada, he became associate professor of political science at the University of New Brunswick (1951-54). In 1954, he joined the office of the deputy minister of Defence Production in Ottawa, and two years later became his executive assistant. In 1960, he was appointed research director of the Royal Commission on Government Organization. Since 1963, he has been assistant secretary to the Cabinet. In the course of his career, Mr. Milligan has served on a number of Canadian delegations to important international conferences, including the 1958 Commonwealth Trade and Economic Conference, the 1958-60 NATO ministerial meetings, the Canada-U.S. joint ministerial meeting on defence (Paris 1958) and the first and second conferences of the Canada and U.S. Interparliamentary Group (1959-60). Mr. Milligan has published several historical papers on the government of Manitoba, and has written on the British nationalized industries and on the financing of Canadian Crown corporations. He also played an important part in the drafting of the Glassco Commission Report of Government Organizations.

NELSON, DR. RICHARD ROBINSON: Economist, The Rand Corporation, Santa Monica California; Born New York City, May 4, 1930. *Education:* B. A. Oberlin College 1952; M. A. Yale University 1952; Ph. D. (Economics) 1956. *Professional Career:* Assistant Professor of Economics Oberlin College 1956-57, Economist, The Rand Corporation, 1957-60; Associate Professor of Economics, Carnegie Institute of Technology 1960-61; In 1961 he was appointed Economist, Council of Economic Advisors. *Subjects of Interest:* Economic Growth; Operations Research; Economic Theory; National Security Economics. *Some Publications:* "Theory of the low level equilibrium trap" (Am. Econ. Rev.); "Simple economics of basic scientific research" (J. Polit. Econ.); "Uncertainty, prediction and competitive equilibrium" (Quart. J. Econ.); "Technology Economic Growth and Public Policy" (in association with M. J. Peck and E. D. Kalachek) The Brookings Institution 1967.

PATTERSON, G. N., Toronto, Ontario. Professor of Fluid Physics and Director, Institute for Aerospace Studies, University of Toronto. An engineering physics graduate of the University of Alberta with postgraduate studies in physics at the University of Toronto. Following university program 4 years at Royal Aircraft Establishment, Farnborough, 6 years with CSIRO in Melbourne, short periods in California and Princeton returning to University of Toronto in 1947 where, since 1949 he has held his present position. Recipient of numerous professional honours and awards and active member of international committees and advisory groups, he is a Fellow of the Royal Aeronautical Society, of the Royal Society of Canada, and of the Canadian Aeronautics and Space Institute.

PETCH, HOWARD EARLE: Date of Birth: May 12, 1925. Citizenship: Canadian. Place of Birth: Agincourt, Ontario. Schools and Universities Attended: Sarnia Collegiate Institute and Technical School, Norwich High School, B.Sc. (Honours Chemistry and Physics), McMaster University, 1949, M.Sc. (Physics), McMaster University, 1950, Ph.D. (Physics), University of British Columbia, 1952, Cambridge University, 1953-54. Scholarships and Other Awards: 1949-52 Research Council of Ontario and National Research Council Scholarships, 1952 British Columbia Academy of Sciences Award, 1953 Rutherford Memorial Postdoctorate Fellowship Awarded jointly by the Royal Society of Canada and N.R.C., 1967 N.R.C. Senior Research Fellowship. Military Record: Served with the Royal Canadian Air Force, 1943-45. Professional Record: 1948 Summer, Mass Spectrometry Laboratory, Polymer Corporation, Sarnia, Ontario, 1949 Summer, Chalk River Laboratories, Atomic Energy of Canada Limited, 1952-53 Postdoctorate Fellow, McMaster University, 1953-54 Rutherford Memorial Fellow, Cavendish Laboratory, Cambridge, 1954-57 Assistant Professor of Physics, McMaster University, 1957-60 Associate Professor Physics (Metallurgy), McMaster University, 1957 Assumed responsibility for developing a metallurgy department, 1958-62 Chairman, Department of Metallurgy and Metallurgical Engineering, McMaster University, 1960-67 Professor of Metallurgy and Metallurgical Engineering, McMaster University, 1964-67 Chairman, Interdisciplinary Materials Research Unit, McMaster University, 1961-67 Director of Research, McMaster University, 1963-67 Principal of Hamilton College, McMaster University. Present Positions: 1967 Professor of Physics, University of Waterloo, 1967 Vice-President, Academic, University of Waterloo. Honours: Honorary Member of Alpha Sigma Mu, 1961 Convocation Founder of Simon Fraser University, 1965 Fellowship in the Royal Society of Canada, 1966. Service on National Science Bodies and Committees: Member, Science Council of Canada, Member of Science Council Committee on Research in Engineering, Member of Science Council Committee on Support of Research in the Universities, Member of Science Council Committee on Annual Review, Chairman, N.R.C. Screening Committee for Chemical and Metallurgical Engineering, Member, N.R.C. Committee on Long Range Programmes and Facilities, Member, Standing Committee on the Sciences, Association of Universities and Colleges of Canada, Director, Canadian Organization for Joint Research. Service on Civic Bodies: Trustee, Ancaster High School Board, 1961-63, Board of Governors, McMaster University, 1965-67, President of local club of Bruce Trail Association during early trail-building stages and also a Director of the Bruce Trail Association, Member, Niagara Escarpment Park Committee, Member, Advisory Board, Great Lakes Institute, University of Toronto, Member, Editorial Advisory Board, "Science Forum". Membership in Societies: American Crystallographic Association, American Physical Society, American Society of Metals, Canadian Association of Physicists, Vice President 1966-67, President 1967-68, Canadian Institute of Mining and Metallurgy (Iron and Steel Branch), Canadian Research Management Association, International Union of Crystallography, Royal Society of Canada.

PORTER, ARTHUR. Personal. Born in Ulverston, Lancashire, England; married; one son. *Education:* B.Sc., Physics, University of Manchester, 1933; M.Sc., Physics, University of Manchester, 1934; Ph.D., Physics, University of Manchester, 1936. *Academic Experience:* 1936-37, Assistant Lecturer, University of Manchester; 1937-39, Postdoctoral Fellow, Department of Physics, Massachusetts Institute of Technology; 1946-49, Professor and Head, Department of Instrument Technology, Royal Military College of Science, Shrivenham, England; 1955-58, Professor, Department of Light Electrical Engineering, Imperial College of Science and Technology, University of London; 1958-61, Dean of Engineering, University of Saskatchewan; 1961-, Professor and Head, Department of Industrial Engineering, University of Toronto; 1967-, Acting Director, Centre for Culture and Technology, University of Toronto. *Professional Experience:* 1939-45, Scientific Officer, Admiralty Research Laboratory, London; 1946, Principal Scientific Officer, National Physical Laboratory, Teddington, England; 1949-55, Head, Research Division, Ferranti Electric Ltd., Toronto. *Memberships:* 1956-58, Member, Executive Committee Marie Curie Memorial Foundation; 1957-58, Member, United Kingdom Radar and Signals Research Board; 1957-58, Member, Epsom Colleger Council; 1958-61, Member, Saskatchewan Research Council; 1963-64, President, Canadian Operational Research Society; 1963-67, Chairman, Advisory Committee for Science and Medecine, World Exhibition Corporation (Montreal); 1967-, Board of Governors, Seneca College of Applied Arts and Technology.

HANS SELYE:

Personal Data:

Nationality:	Canadian
Born:	January 26, 1907, Vienna, Austria
Parents:	Dr. Hugo Selye, Surgeon Maria Felicitas (born Langbank)
Wife:	Gabrielle (born Grant)
Children:	Michel Jean Marie André

Academic Training and Degrees:

1916–24	College of the Benedictine Fathers, Komárom, Hungary
1924–25	Medical Student at German University of Prague, Czechoslovakia
1925–26	Medical Student at University of Paris, France
1926–27	Medical Student at University of Rome, Italy
1927–29	Medical Student at German University of Prague, Czechoslovakia
1929	M.D., German University of Prague, Czechoslovakia
1931	Ph.D. (Organic Chemistry), German University of Prague, Czechoslovakia
1942	D.Sc., McGill University, Montreal, Canada

Honorary Degrees:

1950	Miembro Honorario de las Universidades Nacionales de Argentina (Argentina)

1955 D.Sc. University of Windsor (Canada)
1956 D.Sc. Catholic University of Chile (Chile)
1956 Professor of Medicine Honoris Causa, University of Montevideo (Uruguay)
1959 Professor of Medicine Honoris Causa, Universidad San Carlos (Guatemala)
1962 D.Sc. The Hahnemann Medical College and Hospital of Philadelphia (U.S.A.)

Positions Held:

1929–31 Assistant in Experimental Pathology at University of Prague, Czechoslovakia
1931 Rockefeller Research Fellow at the Department of Biochemical Hygiene, Johns Hopkins University, Baltimore, Maryland, U.S.A.
1932–33 Rockefeller Research Fellow at the Department of Biochemistry, McGill University, Montreal, Canada
1933–34 Lecturer in Biochemistry at McGill University, Montreal, Canada
1934–37 Assistant Professor of Biochemistry at McGill University, Montreal, Canada
1937–41 Assistant Professor of Histology at McGill University, Montreal, Canada
1941–45 Associate Professor of Histology at McGill University, Montreal, Canada
1945 Professor and Director of the "Institut de Médecine et de Chirurgie expérimentales, Université de Montréal", Montreal, Canada
1947-57 Expert Consultant to the Surgeon General, U.S. Army

Medals and Awards:

1946 Casgrain and Charbonneau Prize "for original work leading to improvement in the prevention or treatment of disease" (Montreal, Canada)
1948 Gordon Wilson Medal "for a new concept of the mechanism of certain chronic diseases" (Hot Springs, Virginia, U.S.A.)
1950 The Heberden Research Medal "for research in rheumatic diseases" (London, England)
1950 Medal of Academia Medico Fiscia Fiorentina (Florence, Italy)
1952 Medal of La Sociedad Médico-Quirúrgica del Guayas (Ecuador)
1952 Medal, Fédération Internationale de Médecine Sportive (Paris, France)
1954 Medal, Collège International des Chirurgiens (Switzerland)
1954 Medal, Congresso Internazionale di Terapia (Italy)
1955 Medal, Giornate Mediche Internazionali (Italy)
1955 Honorary Citizen of Verona (Italy)
1955 Diploma Honoris Causa, Archivum Internationalis Gastroenterologiae (Buenos Aires, Argentina)
1955 Semmelweiss Medal "for outstanding scientific work and contribution to science" (New York, U.S.A.)
1956 Diploma de la Academia Mexicana de Gerontología y la Sociedad Mexicana de Geriatría (Mexico)
1957 Certificate of Merit, Hokkaido University (Japan)
1957 Honorary Coat of Arms, University of Tokyo, Faculty of Medicine (Japan)
1958 Centennial Medal, Squibb Institute for Medical Research (U.S.A.)
1959 Honors Awards (2), American College of Angiology (Atlantic City, U.S.A.)
1960 Golden Key of the City of Miami Beach (U.S.A.)
1960 Medal, Fondation Singer Polignac (Paris)
1960 Medal, Société Médicale Belge d'Education Physique et de Sport (Belgium)
1960 Golden Key of the City of San Diego (U.S.A.)
1960 Honorary Award, Western Society of Periodontology (Las Vegas, U.S.A.)
1960 Samuel Charles Miller Memorial Award of the American Academy of Dental Medicine "for significant contributions to the art and science of dental medicine" (Philadelphia, U.S.A.)
1961 Canadian B'nai B'rith Humanitarian Award "for distinguished contribution toward the enrichment of Canadian Life" (Montreal, Canada)
1962 Alexander Vasilievitch Vichnevski Medal and Scientific Counselorship in the A.V. Vasilievitch Institute of Surgery, Academy of Medical Sciences (U.S.S.R.)

1962 Bronfman Prize "for Public Health Achievement" (Montreal, Canada)
1963 Gold Medal, Association Générale des Etudiants de l'Université de Montréal "for outstanding services rendered to the students of the University" (Montreal, Canada)
1963 Honorary Fraternity Pin of "Ilk Ane Instrict Utheris", Dalhousie University (Halifax, Canada)
1964 Medal, Université de Liège (Belgium)
1964 Medal, Société de Médicine de Paris (France)
1964 G. Bourgelat Medal, Ecole Nationale Vétérinaire d'Alfort (France)
1964 J. E. Purkyne Medal, University of Brno (Czechoslovakia)
1964 2nd Prize, Concours littéraires et scientifiques du Québec (Canada)
1964 The Henderson Gold Medal of American Geriatrics Society
1964 Lecture award "for presentation of the first Distinguished Lecture", American Association for the Advancement of Science (U.S.A.)
1965 Honors Achievement Award, Angiology Research Foundation, The Purdue Frederick Company (Montreal, Canada)
1965 Canada's outstanding citizenship award for 1965
1965 Gregor Mendel Medal, Academia Scientiarum Bohemoslovenica (Czechoslovakia)
1965 Grand Cruz de Honor y Mérito, Legión de Honor de la República de Cuba
1965 Sovereign Military Order of S.S. and S. Bridget of Sweden (Rank of Commander)
1965 Medal of the Swedish Medical Society
1965 2nd Prize, Concours littéraires et scientifiques du Québec (Canada)
1966 Pirquet Gold Medal, Pirquet Society of Clinical Medicine (U.S.A.)
1966 Medal, Faculté de médecine, Université de Nancy (France)
1966 New Mexico Dental Association Award, New Mexico (U.S.A.)

Other Diplomas:

1950 U.S. Naval Medical School (Bethesda, Md., U.S.A.)
1950 The Royal College of Physicians and Surgeons of Canada
1959 Phi Delta Epsilon Fraternity (U.S.A.)
1959 Kiwanis Club of Montreal (Canada)
1960 Dalhousie Medical Society (Halifax, Canada)
1960 Club Richelieu (Montreal, Canada)
1960 Alpha Omega Alpha Medical Society (U.S.A.)
1961 Wayne County Medical Society, Beaumont Lecture (Detroit, U.S.A.)
1961 American Urological Association, Ramon Guiteras Lecture (Los Angeles, U.S.A.)
1964 College of Osteopathic Medicine and Surgery (Des Moines, Iowa, U.S.A.)
1964 Canadian Cardiovascular Society
1964 Lions Club (Montreal, Canada)

Fellow of the following Societies:

1941 Royal Society of Canada
1948 New York Academy of Sciences
1949 American Association for the Advancement of Science
1959 American Geriatrics Society

Member of the following Societies:

Aerospace Medical Association
American Association for Cancer Research, Inc.
American Association of Anatomists (retired)
American Heart Association (Founder Member of the Scientific Council)
American Physiological Society
American Society for Clinical Investigation
American Society for the Study of Arteriosclerosis
Association Belge de Cancérologie (Membre du Comité Scientifique)

Association Canadienne-Française pour l'Avancement des Sciences
Association des Médecins de Langue Française du Canada
Association of the Physicians from Slovakia
Canadian Authors Association
Canadian Inter-American Association, Inc.
Canadian Medical Association
Canadian Neurosurgical Society
Canadian Physiological Society
Canadian Society for the Study of Allergy
Club de Recherches Cliniques du Québec
Collegium Internationale Allergologicum, England (Founder Member)
Collegium Medicorum et Chirurgorum (Quebec)
Comité de Patronage et du Conseil Scientifique de la Fondation des Frères Lumière (Switzerland)
Comité du "Prix international d'angéiologie" et Comité de Direction des Archives internationales d'angéiologie du Conseil de l'Athenaeum Medicum Santorianum (Italy)
Endocrine Society (U.S.A.)
Federation of American Societies for Experimental Biology
Foundation for Aging Research, N.Y. (Member of Scientific Advisory Board, U.S.A.)
Montreal Medico-Chirurgical Society (retired)
Montreal Physiological Society (President, 1943-44)
New York Academy of Sciences
Pan American Medical Association (North American Chairman, Section on Endocrinology)
Pharmacological Society of Canada (Charter Member)
Societas pro Rhythmo Biologico (Sweden)
Société de Biologie de Montréal (President, 1951-52)
Société d'Endocrinologie (France)
Society for Endocrinology (England, Founder Member, 1946)
Society for Experimental Biology and Medicine (U.S.A.)
The Library Association (London, England)
The Royal Society of Medicine, England (Affiliate)
The Society of the Sigma XI (McGill Chapter)

Honorary Fellow or Member of the following Societies:

1942 Sociedad de Biologia de Santiago (Chile)
1945 Russian Endocrinological Society (U.S.S.R.)
1947 Svenska Endokrinologoföreningen (Sweden)
1948 Aesculapian Society of the University of Ottawa (Canada)
1948 American Clinical and Climatological Association (U.S.A.)
1949 Essex County Pathological and Anatomical Society (U.S.A.)
1949 New Mexico Clinical Society (U.S.A.)
1949 Sociedad Argentina de Biología (Argentina)
1949 Sociedad Endocrinologia Bohemica (Czechoslovakia)
1950 Sociedad Médico-Quirúrgica del Guayas (Ecuador)
1951 Heberden Society (England)
1952 Pan American Medical Association (U.S.A.)
1952 Sociedade de Biologia do Rio Grande do Sul (Brazil)
1952 Sociedade de Endocrinologia e de Metabologia do Rio de Janeiro (Brazil)
1952 Sociedade de Medicina de Porto Alegre (Brazil)
1952 Société de Pathologie comparée (France)
1953 Sociedad Colombiana de Endocrinología (Colombia)
1954 International College of Surgeons (Switzerland)
1954 Società Lombarda di Scienze Mediche e Biologiche (Italy)
1954 Society of Graduate Surgeons of the Los Angeles County Hospital Inc. (U.S.A.)
1955 American-Hungarian Medical Association. Life member (U.S.A.)
1956 Sociedad Médica de Santiago (Chile)

1956 Sociedad de Biología de Montevideo (Uruguay)
1956 Asociación Venezolana para el Avance de la Ciéncia (Venezuela)
1957 Center for the Coagulation of Blood, Capillar and Practical Research on Muscles (Hungary)
1957 Institut d'Endocrinologie, Conseiller d'honneur (Haïti)
1959 Sociedad de Endocrinología y Metabología (Mexico)
1960 National Institute of Sciences of India (India)
1960 Academia Medica di Roma (Italy)
1960 Asociación Argentina de Alergia e Immunología (Argentina)
1960 Austrian Society of Canada, Honorary President (Canada)
1961 The Institute "Alexander of Tralles" of Medicine, Imperial Philo-Byzantine Academy (Academic member)
1962 International Medical Club of Washington (U.S.A.)
1963 Indian Society of Endocrinology (India)
1963 Ateneo Privado de Actualizaciones e Investigationes Médicas (Argentina)
1964 North Pacific Society of Neurology and Psychiatry (U.S.A.)
1964 Société de Médecine de Paris (France)
1964 Zoological Society of Calcutta (India)
1965 Československá Lékařská Společnost J.E. Purkyně (Czechoslovakia)
1966 Patron of Creative Awards Association (Westmount, Canada)
1966 Pirquet Society of Clinical Medicine (U.S.A.)
1966 New York Orthopaedic Hospital (U.S.A.)

Corresponding Member of the following Societies:

Academia National de Medicina de Buenos Aires (Argentina)
American Medical Authors, Inc. (U.S.A.)
American Mental Health Foundation, Inc. (U.S.A.)
Asociación Médica Argentina (Argentina)
Preventive Heart Reconditioning Foundation (U.S.A.)
Real Academia Nacional de Medicina (Spain)
Sociedad Argentina de Biología (Argentina)
Sociedade Portuguesa de Endocrinologia (Portugal)
Società Italiana di Endocrinologia (Italy)
Société de Médecine de Paris (France)
Société d'Endocrinologie de Paris (France)
Société Philomathique de Paris (France)
Wiener Gesellschaft für Innere Medizin (Austria)

Member of the Editorial Board of:

Acta Anatomica (Switzerland)
American Journal of Cardiology (U.S.A.)
American Journal of Proctology (U.S.A.)
Angiology (U.S.A.)
Archivio Italiano di Endocrinologia (Italy)
Arzneimittel-Forschung (Germany)
Biochemical Clinics (U.S.A.)
Excerpta Medica (The Netherlands)
Experimental Medicine and Surgery (U.S.A.)
Folia Clínica Internacional (Spain)
Indian Journal of Endocrinology and Metabolism (India)
International Archives of Allergy and Applied Immunology (Sweden)
International Journal of Medicine (U.S.A.)
Journal de Physiologie (France)
La Semana Médica (Argentina)
MD Medical Newsmagazine (U.S.A.)
Medical Digest (U.S.A.)
Medicus (Pakistan)
Revue de Médecine Fonctionnelle (Switzerland)
Science Citation Index, Institute for Scientific Information (U.S.A.)

World-Wide Abstracts of General Medicine (U.S.A.)

Author of the following books:

ENCYCLOPEDIA OF ENDOCRINOLOGY. Section I: CLASSIFIED INDEX OF THE STEROID HORMONES AND RELATED COMPOUNDS (4 vols.) Montreal: A.W.T. Franks Publ. Co., 1943

ENCYCLOPEDIA OF ENDOCRINOLOGY. Section IV: THE OVARY (2 vols.) Montreal: Richardson, Bond X Wright, 1946

TEXTBOOK OF ENDOCRINOLOGY. Montreal: Acta Inc., Med. Publ., First ed. 1947; Second ed. 1949

Translations:

Italian: "Trattato di endocrinologia" by C. Cavallero (Milan: Casa Editrice Ambrosiana, 1952)

Japanese: "Shin-nai-bun-pitz-Gaku" by K. Tatai (Tokyo: Ishiyaku Publ., Inc., 1956

Spanish: "Endocrinología" by J.M. Cañadell (Barcelona, Madrid, Buenos Aires, Mexico, Rio de Janeiro: Salvat Editores, S.A., 1952)

ON THE EXPERIMENTAL MORPHOLOGY OF THE ADRENAL CORTEX. (In collaboration with H. Stone) Springfield: Charles C. Thomas Publ., 1950

STRESS. Montreal: Acta Inc., Med. Publ., 1950

Translations:

Italian: "Stress" by P. Gioannini (Turin: Edizıoni Scientifiche Einaudi, 1957)

Spanish: "Stress (sufrimiento)" by J. Morros Sarda, including translation of First Annual Report on Stress by J.M. Cañadell (2 vols.) (Barcelona: Editorial Científico-Médica, 1954)

THE STRESS OF LIFE. New York: McGraw-Hill, 1956

Translations:

French: "Le stress de la vie" by P. Verdun and M. Barath (Paris: Editions Gallimard, 1962)

German: "Stress beherrscht unser Leben" by H. Sopp and P. Klärner (Düsseldorf: Econ Verlag, 1957)

Hungarian: "Eletünk és a stress" by M. Both (Budapest: Akadémiai Kiadó, 1963)

Japanese: "Gen-dai Sei-katzu to Stress" by Y. Sugi, K. Tatai, N. Fujii and T. Takemiya (Tokyo: Hosei University Press, 1963)

Polish: "Stress zycia" by J.W. Gusek and R. Rembiesa (Warsaw: Panstwowy Zaklad Wydawnictw Lekarskich, 1963)

Portuguese: "Stress—a tensão da vida" by F. Branco (São Paulo: Ibrasa-Instituição Brasileira de Difusão Cultural, S.A., 1959)

Spanish: "La tensión en la vida—El stress" by J. Curutchet (Buenos Aires: Comp. Gen. Fabril, Edit., S.A., 1960)

Swedish: "Stress" by B. Bernholm (Stockholm: Natur och Kultur, 1958)

ANNUAL REPORTS ON STRESS. (In collaboration with G. Heuser and A. Horava) Volumes I-V, Montreal: Acta Inc., Med. Publ., 1951-55/56

THE STORY OF THE ADAPTATION SYNDROME. Montreal: Acta Inc., Med. Publ., 1952

Translations:

French: "L'histoire du syndrome général d'adaptation" by J. Tchékoff and P. Caplier (Paris: Librairie Gallimard, 1954)

German: "Einführung in die Lehre-vom Adaptationssyndrom" by H. Köbcke, R. Hoene and G. Heuser (Stuttgart: Georg Thieme Verlag, 1953)

Interlingua: "Le historia del syndrome de adaptation", selected excerpts "by A. Gode" (New York: Science Service, Interlingua Division, 1953)

Italian: "La sindrome di adattamento". Preface "by A. de Barbieri" (Milano: Istituto Sieroterapico Milanese, 1955)

Japanese: "Teki-o shyo-ko Gung" by G. Tatai (Tokyo: Ishiyaku Publ., Inc., 1953)

Russian: "Ocherby ob adaptatsionnom sindrome" by V. I. Kandrora and A.A. Rogova (Moscow: Medgiz, 1960)

SYMBOLIC SHORTHAND SYSTEM FOR PHYSIOLOGY AND MEDICINE. (In collaboration with M. Nadasdi and P. Prioreschi) Montreal: Acta Inc., Med. Publ., First ed. 1956; Second ed. 1958; Third ed. 1960; Fourth ed. (in collaboration with G. Ember), Montreal: IMCE, Université de Montréal, 1964.

THE CHEMICAL PREVENTION OF CARDIAC NECROSES. New York: The Ronald Press Co., 1958

Translations:

German: "Elektrolyte, Stress und Herznekrose" by L. and U. Gruber-Jucker (Basel/Stuttgart: Benno Schwabe Verlag, 1960)

Russian: "Profilaktika nekrozov serdtsa khimicheskimi sredstvami" by V. I. Kandora (Moscow: Medgiz, 1961)

Polish: "Zapobieganie, martwicy miesnia sercowego srodkami chemicznymi" by J. Goldstein (Warsaw: Pañstwowy Zaklad Wydawnictw Lekarskich, 1963)

THE PLURICAUSAL CARDIOPATHIES. Springfield: Charles C. Thomas Publ., 1961

CALCIPHYLAXIS. Chicago: The University of Chicago Press, 1962

FROM DREAM TO DISCOVERY. New York: McGraw-Hill, 1964

Translation:

German: "Vom Traum zur Entdeckung" by H.J. von Koskull and Elfie Staub (Düsseldorf: Econ Verlag, 1965)

THE MAST CELLS. Washington: Butterworth Inc., 1965

THROMBOHEMORRHAGIC PHENOMENA. Springfield: Charles C. Thomas Publ., 1966

PRINCIPAL RESEARCH TOPICS

Stress

Description of the *General Adaptation Syndrome* (*G.A.S.*) as the bodies response to stress as such; especially, participation of the "pituitary-adrenocortical axis" in nonspecific defense.

Development of the concept of the *diseases of adaptation* as maladies in which derangements of the G.A.S. play a decisive role.

Hormonal conditioning, the influence of hormones upon reactivity.

Factors influencing the development of *cardiac necroses* and related lesions (electrolytes, hormones, antimineralocorticoids, stress).

Local and systemic nonspecific *cross-resistance*, the induction of topical or general tolerance to an agent by pretreatment with stressors.

Hormonal production of hypertension, nephrosclerosis, and generalized experimental collagen diseases (by mineralocorticoids and STH).

Calciphylaxis and Calcergy

Thrombohemorrhagic Phenomena (THP)

Acute Conditioned Necrosis (ACN)

Pluricausal Diseases

Anaphylactoid Inflammation

Steroid Anesthesia

MINOR RESEARCH TOPICS

The neurohumoral reflex of lactation ("suckling pseudopregnancy").

Development of various experimental techniques, such as:

Procedures for hypophysectomy and cardiac surgery in the rat;

Formalin-arthritis test;

Granuloma-pouch technique for the study of inflammation;
"Endocrine-kidney" technique;

Mechanical "tissue scaffoldings" for the topical induction of growth, metaplasia and malignancy.

ADDENDUM

Honorary degrees: 1966 M.D. Westfälische Wilhelms Universität, Münster (Germany), 1967 M.D. University of Cagliari (Italy), 1967 M.D. Karl-Franzens University, Graz (Austria). Medals and awards: 1967 Honorary Citizen, The State of Texas (U.S.A.), 1967 Award of the 700,000th LEITZ Microscope, Wetzlar (Germany), 1967 Southern California Dental Association Award (U.S.A.), 1967 The Thomas P. Hinman Clinic Award, Atlanta (U.S.A.), 1967 The Centennial Medal (Canada), 1967 Claude Bernard Medal, Université de Montréal (Canada), 1967 George Washington Medal, American Hungarian Studies Foundation (U.S.A.). Member of the following societies: Advisory Council of the Clinical Forum for Conscience of the Medical Research Foundation, Philadelphia (U.S.A.), Japanese Circulation Society (Japan) International Center for Integrative Studies, N.Y. (Member of the Board of Sponsors, U.S.A.), ARPAD Akademia, Hungarian Association (Ohio, U.S.A.), Société Canadienne d'Endocrinologie, Association for the Study of Internal Secretions (U.S.A.), Société Belge de Chirurgie. Honorary fellow or member of the following societies: 1966 The Pacific Dermatologic Association Inc. (U.S.A.), 1967 International Institute of Scientific Cooperation (Germany), 1967 Louisiana Psychiatric Association (U.S.A.), 1968 Polish Society of Endocrinology. Corresponding member of the following societies: The Institution of Nuclear Engineers, International, Nuclear Hematology Section (England). Member of the editorial board of: Ars Medici (Belgium), Experimentelle Chirurgie (Germany), American Journal of Clinical Hypnosis, International Journal of Neuropsychiatry. Author of the following books: THE MAST CELLS. Washington: Butterworth, 1965, THROMBOHEMORRHAGIC PHENOMENA. Springfield: Charles C. Thomas Publ., 1966, IN VIVO. New York: Liveright 1967 ANAPHYLACTOID EDEMA. St. Louis, Mo.: Warren H. Green, 1968.

OMOND M. SOLANDT—Dr. Solandt (O.B.E., M.A., M.D., D.Sc., LL.D., F.R.C.P., F.R.S.C.) was born in Winnipeg, Manitoba. He obtained a B.A. in Biological and Medical Sciences at the University of Toronto in 1931. He spent the next two years in post-graduate research under Dr. C. H. Best in the Department of Physiology, Faculty of Medicine, University of Toronto, and obtained an M.A. He took his Doctorate from the Faculty of Medicine in 1936 and was awarded the Gold Medal. He also played on the senior intercollegiate football team. Following graduation from the Faculty of Medicine, he spent a year in research at Cambridge and a year as an intern at the Toronto General Hospital. In 1939, after post-graduate work at the London Hospital, he received the M.R.C.P. (London) and then returned to Cambridge as a lecturer in Physiology and a member of the teaching staff at Trinity Hall. Shortly after the outbreak of war, he was appointed Director of the Southwest London Blood Supply Depot and continued in that capacity until January 1941. He founded the Medical Research Council's Physiological Laboratory at the Armoured Fighting Vehicle School at Lulworth, and became actively engaged in research concerned with tank design and the physiological problems peculiar to tank personnel. In 1942, he turned from medical research to the then new field of operational research and formed the Armoured Fighting Vehicle Section of the Army Operational Research Group. The following year, he was appointed Deputy Superintendent, Army Operational Research Group and in May 1944, Superintendent. He joined the Canadian Army in February 1944 and left the Army in 1946 as a Colonel. In September 1945 he was sent to Japan by the War Office as a member of a mission to evaluate the effects of the atomic bomb. Dr. Solandt returned to the Department of National Defence in Ottawa in 1946 to begin planning for a permanent defence research organization in Canada. This work resulted in the formation of the Defence Research Board in 1947. Dr. Solandt became the first Chairman of the Board and the scientific member of the Chiefs of Staff Committee and Defence Council. In 1956, he left the Defence Research Board to become Vice-President, Research and Development, of the Canadian National Railways. In 1963, he left the CN to become Vice-President, Research and Development, and a Director of The de Havilland Aircraft of Canada, Limited, and Hawker Siddeley Canada Ltd., and Chairman of the Board of DCF Systems Limited. In 1966, he left these positions to become Chairman of the Science Council of Canada and Vice Chairman of the Board of The Electric Reduction Co. He is also a Director of the Huyck Corporation and of EXPO 67. Dr. Solandt was awarded the O.B.E. in 1946, and the U.S. Medal of Freedom with Bronze Palm in 1947. He received the honorary degree of D.Sc. from the University of British Columbia in 1947, from Laval University in 1948, from the University of Manitoba in 1950, from McGill University in 1951, from St. Francis Xavier University in 1956, from Royal Military College in 1966, and from the University of Montreal in 1967; and, an LL.D. from Dalhousie University in 1952, and from the University of Toronto in 1954. He was elected a Fellow of the Royal Society of Canada (Section III) in 1948, and an Honorary Member of the Engineering Institute of Canada. In 1956 he was awarded the Gold Medal of the Professional Institute of Canada and in 1961 he received the Civic Award of Merit from the City of Toronto. He was President of the Canadian Operational Research Society from 1958-60 and a Governor of Sir George Williams University, Montreal, from 1957-63. He was formerly a Governor of The University of Toronto and of the Arctic Institute of North America, and President of the Royal Canadian Geographical Society. He is at present a Trustee of the Mitre Corporation, Boston, a Director of the Canadian Corporation for the 1967 World Exhibition; a Fellow of the Royal College of Physicians in London, and was elected Chancellor of the University of Toronto in 1965. Dr. Solandt was a member of the Western Team at the Conference of Experts to Study the Methods of Detecting Violations of a Possible Agreement on the Suspension of Nuclear Tests, held in Geneva in 1958. Dr. Solandt has a wide variety of interests, including flying and radio. He secured a commercial radio operator's license before entering university and worked as an observer with the Ontario Provincial Air Service. He is married to the former Elizabeth McPhedran of Toronto and has three children: Sigrid, Andrew and Katharine. He is a member of the St. James's Club, Montreal, the University Club, Montreal, the Rideau Club, Ottawa, the Athenaeum Club, London, England, the York Club, Toronto, and of Bloor Street United Church in Toronto.

Weir, John Robert. B.S.A., M.Sc., Ph.D., D.Sc., F.A.I.C., F.A.A.A.S., F.R.S.A. Dr. Weir was born in Wingham, Ontario, on October 17, 1912. He attended Wingham High School and Stratford Normal School prior to beginning his studies in agriculture. Following graduation from the University of Toronto in agriculture Dr. Weir attended the University of Alberta where he obtained his M.Sc. (1938) and the University of Minnesota where he obtained his Ph.D. (1944). He held research assistantships at both these universities. His graduate studies were in plant genetics and plant physiology. He joined the Department of Field Husbandry at the Ontario Agricultural College in 1940 and remained with the Department for 12 years, advancing from Lecturer to Professor. In 1952 he accepted the position of Dean of the Faculty of Agriculture and Home Economics at the University of Manitoba, leaving there in July 1965 to become Deputy Director of the Science Secretariat. He became Director of the Science Secretariat in July 1967. In May 1966 Dr. Weir was awarded the honorary degree of Doctor of Science by the University of Manitoba. Dr. Weir is a Fellow of the Agricultural Institute of Canada, and in 1962 was the National President of that Institute. He is also a Fellow of the American Association for the Advancement of Science and of the Royal Society of Arts. He was a member of several Senate Committees of the University of Manitoba as well as various federal and provincial agricultural advisory committees and has served on the Committee of Deans of Agriculture and Veterinary Medicine. In 1959 he was an official Canadian delegate at the Conference on Higher Education in Agriculture held in Paris and sponsored by the Organization for European Economic Co-operation and has attended numerous other international scientific meetings. He was Chairman of the 1961 Steering Committee of the National Conference on Farm Policy Research and Chairman of the Research Directorate, Agricultural Economics Research Council of Canada. He is a former director of the Manitoba Cancer Relief and Research Institute, 1953-57, and was a member of the Manitoba Research Council, 1963-65, as well as the American Genetic Association and the Canadian Corporation for the 1967 World Exhibition. In 1961 he was invited to serve on the Royal Commission on Government Organization (Glassco Commission) and spent almost the whole of that year on a study of the scientific and industrial research activities of the Canadian Government. In 1964 Dr. Weir served as a consultant to the Ford Foundation on university organization in Brazil, and in 1966 he was appointed Chairman of a Commission for Agricultural Education in Kenya by the Rockefeller Foundation. He was a guest speaker at a plenary session of the Fourth Commonwealth Education Conference in Lagos, Nigeria in February 1968. In the past few years he has visited research and educational institutions in Western Europe, the British Isles, Australia, New Zealand, Brazil, South America, the West Indies and Eastern and Western Africa.

Dr. Weir is married to the former Nora Hiscocks of Teeswater, Ontario. They have two sons, Robert and John.

Whitehead, James Rennie. B.Sc. (Manc.) Ph.D. (Cantab.) Dr. J. Rennie Whitehead was born in Lancashire, England, on August 4, 1917. Following graduation in Physics from Manchester University in 1939, he entered the Telecommunications Research Establishment (now the Royal Radar Establishment at Malvern, Worcestershire). He designed the Mark III I.F.F. air-borne and ship-borne transponder and later headed the radar identification group. He was also secretary of a sub-committee of the War Cabinet Operations and Technical Committee. In 1944, he was a member of a War Cabinet Mission to the Combined Chiefs of Staff in Washington, and he spent a year on scientific liaison in Washington, D.C. On his return to the United Kingdom in November, 1945, Dr. Whitehead became head of a research group on pulsed light and millimetre waves which, in 1946, made the first experimental operating radar on a wavelength below one centimetre. The same year, he went on loan to the University of Cambridge as a consultant in electronics to a group on the Physics and Chemistry of Solids. At Cambridge, in 1949, he obtained his doctorate degree in the Department of Physical Chemistry, and wrote the book, "Superregenerative Receivers", on the principles behind his war-time radar work. Dr. Whitehead emigrated to Canada in 1951 and joined the Eaton Electronics Research Laboratory of McGill University. While Associate Professor of Physics at McGill during the years 1951-55, he was responsible, on behalf of the Defence Research Board, for the major research and development associated with the "McGill Fence" (Mid-Canada Line). In 1955, Dr. Whitehead joined the RCA Victor Company, Ltd., Montreal, as Director of Research, with responsibility for initiating and developing research laboratories which are now extensive. In 1961, he was invited to serve on the Royal Commission on Government Organization and spent the greater part of that year on a study of the scientific and industrial research activities of the Canadian Government. On May 31, 1965, Dr. Whitehead was appointed a Deputy Director of the Science Secretariat, Privy Council Office. On July 1, 1967 he was appointed Principal Science Adviser. Dr. Whitehead is a Fellow of the Institute of Physics and of the Institution of Electrical Engineers, and an Associate Fellow of the Canadian Aeronautics and Space Institute. He is a Senior Member of the Institute of Electrical and Electronic Engineers, and a Member of the Canadian Association of Physicists, the American Physical Society and Sigma XI. He is a Professional Engineer of the Province of Ontario, and has been for several years on the Board of the Canadian Research Management Association.

Wright, Christopher: Born 31 October 1926 at Chicago, Illinois. Married 1956, a son born in 1960 and a daughter born in 1961. Addresses: Columbia University, 662 West 113th Street, New York, N.Y. 10027. 21 Claremont Avenue, New York, N.Y. 10027. Education: 1944 University of Chicago. 1946-1949 Harvard College, Philosophy B.A. 1949 Magna Cum Laude, Phi Beta Kappa. 1949 Harvard University, passed general ("preliminary") examinations for Ph.D. candidates in philosophy. 1949-1951 Oxford Unixersity, Fulbright Grantee with status of Advanced Student reading in social and political philosophy and scientific methods. 1951-1955 Harvard University, completed all requirements for Ph.D. in philosophy except for submission of an acceptable dissertation. Military service: 1945-1946 U.S. Army Corps of Engineers, Special Engineering Detachment (Los Alamos, N.M.), inducted as a private, discharged as a technical sergeant (T/4), scientific research work as specified below. Experience: 1944-1946 Manhattan Project (University of Chicago and Los Alamos), served alternately as a civilian, in the Army Corps of Engineers, then as a civilian again according to the convenience of the Government. The work involved electronic instrumentation, experimental design for the plutonium bomb, special assignment at first test shot at Alamagordo, and designs for first Fast Neutron Reactor. Particular concerns in connection with reactor design were critical mass measurements, shielding control mechanisms, and the research facilities and building for the reactor. 1941-1955 Teaching Fellow at Harvard College; Courses in General Education (social science) and in Philosophy (1942-1954); Resident Tutor, Lowell House, Harvard College. 1954

Instructor in Philosophy, William College, Williamstown, Massachusetts; Courses in systematic philosophy and theories of knowledge (Spring Term). 1956-1958 Research Associate, University of Chicago Law School Research, within the Law School Arbitration Project involving study and analysis of a variety of mechanisms for settling and avoiding commercial disputes in domestic and international contexts. This research required understanding of trade patterns for commodities and manufactured goods (including "input-output" patterns), of IBM punch card techniques, and of theories concerning ideas of justice, the settlement of disputes, and the growth and functions of organizations. 1958 Associate Director (1958-1959), Executive Director (1959-1960) Columbia University Council for Atomic Age Studies; Primary responsibility was for developing research programs, teaching, administration and the preparation of special studies. The Council facilitated interdisciplinary research studies of major problems associated with particular developments in many areas of science and technology as these affect human affairs, such as foreign relations, national policymaking, government organization and education. Attention was also given to the ways in which social activities affect the advance of science. 1963 Lecturer, Department of Public Law and Government, Columbia University; Offering a one-term upper level College course "Government and Science: U.S., U.K., and the U.S.S.R.". A seminar "Science and Society" was offered in the College Philosophy Department (Spring, 1961). 1966 Director, Institute for the Study of Science in Human Affairs, Columbia University. Professional activities: Consultant: Brookings Institution (1960), Carnegie Endowment for International Peace (1961-), Foreign Service Institute, Department of State (1964-1965), Commission for Marine Science, Engineering and Resources (1967), and other organizations. Participant in various conferences and seminars including ones sponsored by the American Assembly, American Association for the Advancement of Science, American Association for Asian Studies, Aspen Institute for Humanities Studies, Council on Foreign Relations (N.Y.), the Institute of Air and Space Law, McGill University, the National Academy of Sciences, etc. Also testified before the Senate Subcommittee on Government Research (1967) and the House of Representatives Subcommittee on Science, Research and Development (1967). Member and on the steering committees of the Columbia University Seminars on "Problems of Peace" and on "Technology and Social Change". Member Commission on the Year 2000, American Academy of Arts and Sciences (1966-). Major research interests: Science in human affairs: Government and science, science and world affairs. Social and political philosophy: Language, Law, and government; institutional mechanisms for dispute settlement and avoidance. Social science methodology: Possible uses and abuses of systems analysis, data processing capabilities, and computerized models of social institutions. Publications: books: *Scientists and National Policy-Making*, New York: Columbia University Press, 1964. Contributor and Co-editor with Robert Gilpin. Articles and book Chapters: "Scientific Progress and the Government of Outer Space", *Journal of International Affairs*, Vol. XIII, No. 1 (1959), pp. 78-92. "Selected Critical Bibliography on Arms Control", *Daedalus*, [Special Issue on Arms Control] Vol. 89, No. 4 (Fall 1960), pp. 1055-70. "United Nations and Space", *Bulletin of the Atomic Scientists*, Vol. XVII, Nos. 5-6 (May-June, 1961), pp. 236-40; reprinted (revised) in: "Outer Space and the United Nations", a chapter in *Challenge of Space*, edited by Hugh Odishaw, Chicago: University of Chicago Press, 1962. "General Implications of Peaceful Space Activities for Inter-National Affairs and Foreign Policy", a section of *Proposed Studies on the Implications of Peaceful Space Activities for Human Affairs*, prepared for

NASA and edited by Donal N. Michael, Washington, D.C.: Brookings Institution, 1961. "Introduction" to *The Impact of Science on Technology,* edited by Aaron Warner et al. New York: Columbia University Press, 1965. "Prospects for Science and Man in America in Mid-Twentieth Century" *UNESCO Journal of World History,* Vol. VIII, No. 4 (1965) pp. 789-811. "The Study of Sicence in Human Affairs", *Newsletter,* American Council of Learned Societies, Vol. XVIII, No. 5 (May, 1967) pp. 1-6. *Book reviews*: 'The Department of Scientific and Industrial Research' by Sir Harry Melville. Political Science Quarterly, No. 1 (1963). 'Invisible Government' by David Wise and Thomas B. Ross. *Political Science Quarterly,* Vol. LXXXII, No. 1 (March, 1967), 'In the Name of Science' by H. L. Nieburg. *Midwest Journal of Political Science,* Vol. XI, No. 3 (August, 1967), 'Science, Technology, and American Foreign Policy' by Eugene B. Skolnikoff. *Science,* Vol. 156, No. 3780 (June 9, 1967), 'The Politics of Pure Science' by Daniel S. Greenburg. *Technology and Culture* (to be published in 1968).

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