

AGENCY FOR INTERNATIONAL DEVELOPMENT  
WASHINGTON, D. C. 20523

**BIBLIOGRAPHIC INPUT SHEET**

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*Bottle 39*

1. SUBJECT CLASSIFICATION	A. PRIMARY	TEMPORARY
	B. SECONDARY	

2. TITLE AND SUBTITLE  
Report and recommendations (of the Workshop)

3. AUTHOR(S)  
(101) Workshop on Science and Technology In Development, Fusagasuga, Colombia, 1968

4. DOCUMENT DATE 1968	5. NUMBER OF PAGES 64p.	6. ARC NUMBER ARC C0330.9861.N277
--------------------------	----------------------------	--------------------------------------

7. REFERENCE ORGANIZATION NAME AND ADDRESS  
NAS

8. SUPPLEMENTARY NOTES (*Sponsoring Organization, Publishers, Availability*)  
(Contributed papers given at this jointly sponsored Colombia-U.S. Workshop, v.2 of the final Workshop report, available: PN-AAC-432)

9. ABSTRACT

(Sci. & Tech. R&D)

10. CONTROL NUMBER PN-AAC-431	11. PRICE OF DOCUMENT
12. DESCRIPTORS	13. PROJECT NUMBER
	14. CONTRACT NUMBER CSD-1122 GTS
	15. TYPE OF DOCUMENT

CSQ-1122 GTS  
PN-AAC-431

*Report of*  
*the*  
Colombia-U. S. Workshop  
on Science and Technology  
in Development

February 26-March 1, 1968  
FUSAGASUGA, COLOMBIA

*VOLUME I*

NATIONAL ACADEMY OF SCIENCES  
In Cooperation with the  
COLOMBIAN MINISTRY OF EDUCATION

This report records the topics discussed and conclusions reached at the Colombia-U.S. Workshop on Science and Technology in Development held in Fusagasugá, Colombia, February 26-March 1, 1968. It is compiled from reports of session rapporteurs, as well as staff notes. The workshop was jointly sponsored by the National Academy of Sciences and the Colombian Ministry of National Education, under contract AID/csd 1122. This report will be presented to the Science Organization Development Board of the National Academy of Sciences and to the Agency for International Development, as well as to interested institutions in Colombia. This workshop is part of a continuing study and program of science organization and development in a number of countries, undertaken by the National Academy of Sciences.

Report of the  
COLOMBIA - U.S.  
WORKSHOP ON SCIENCE AND TECHNOLOGY IN DEVELOPMENT

Fusagasugá, Colombia  
February 26 - March 1, 1968

Volume I  
Report and Recommendations

Office of the Foreign Secretary  
National Academy of Sciences

In Cooperation with the  
Colombian Ministry of National Education

NATIONAL ACADEMY OF SCIENCES  
Washington, D. C.

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Ing. Faustino Martínez (Reports), President, Colombian Association  
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Bogotá

## A G E N D A

Monday, February 26

**SESSION I**  
4:00-8:00 p.m.      **Chairman:** Minister Betancur  
**Rapporteurs:** Dr. George Waggoner  
Dr. Oliverio Phillips

Science Policy and Economic Development

**Speakers:** Dr. Harrison Brown  
Mr. Carroll Wilson

Tuesday, February 27

**SESSION II**  
8:30 a.m.-12:30  
p.m.      **Chairman:** Dr. Carl Djerassi  
**Rapporteurs:** Mr. Keith Glennan  
Dr. Jaime Sanín

The Need for a Colombian Science Policy for Science  
and Technology

**Speaker:** Minister Betancur

Current Educational Research in Colombia

**Speakers:** Dr. Aurelio Céspedes  
Dr. Enrique Ruffat  
Dr. Javier Arias

**SESSION III**  
3:00-8:30 p.m.      **Chairman:** Dr. Stanley Cain  
**Rapporteurs:** Mr. Hans Landsberg  
Dr. Norton Young

Technological Problems in Agricultural Development

**Speakers:** Dr. Guillermo Guerra  
Dr. Canuto Cardona

Non-Renewable Resources in Colombia

**Speaker:** Dr. Darío Suescún

Problems in the Development of Research

**Speakers:** Dr. Zven Zethelius  
Dr. Ramiro Tobón

**SPECIAL SESSION**  
9:30 p.m.      Advanced Technological Approaches to Education  
**Speaker:** Dr. William Bollay

Wednesday, February 28

SESSION IV  
8:30 a.m.-12:30 p.m.

Chairman: Dr. Oliverio Phillips  
Rapporteurs: Dr. Dwight Brothers  
Dr. Faustino Martínez

Technological Problems in Industrial Development

Speakers: Dr. Gabriel Poveda  
Dr. Manual Carvajal  
Dr. Rodrigo Uribe  
Dr. Karl Folkers

WORK GROUP MEETINGS  
2:00-8:30 p.m.

1. Education

Dr. George Waggoner (Chairman)  
Dr. Gabriel Betancur  
Dr. Aurelio Céspedes  
Dr. Carl Djerassi  
Dr. Gerardo Eusse  
Mr. Keith Glennan  
Ing. Alberto Ospina  
Dr. Jaime Sanín  
Dr. Edward Schten  
Dr. Ramiro Tobón  
Dr. Zven Zethelius

2. Agriculture and Natural Resources

Dr. Joaquín Piñeros (Chairman)  
Dr. Harrison Brown  
Dr. Stanley Cain  
Dr. Canuto Cardona  
Mr. Hans Landsberg  
Dr. Tulio Marulanda  
Dr. Foster Montgomery  
Dr. Jesús Ramírez  
Dr. Dario Suescún  
Dr. Norton Young  
Dr. Robert Waugh

3. Industry

Dr. Rodrigo Botero  
Dr. Dwight Brothers  
Dr. Manuel Carvajal  
Dr. Karl Folkers  
Dr. Faustino Martínez  
Dr. Luis Ospina

3. Industry (cont'd)  
Dr. Gabriel Poveda  
Dr. Rodrigo Uribe  
Mr. Carroll Wilson

4. Policy for Science and Technology  
Dr. Gabriel Betancur  
Dr. Harrison Brown  
Chairmen of work  
groups

Thursday, February 29

8:30 a.m.-12:30 p.m. Preparation and Discussion of Work Group  
Reports

SESSION V Chairman: Dr. Harrison Brown

2:00-6:00 p.m. Discussion of Work Group Reports and  
Approval of Recommendations

CLOSING SESSION Chairman: Minister Betancur  
8:15 p.m.

Friday, March 1

11:00 a.m. Meeting with President Lleras, San Carlos  
Palace

6:30 p.m. Reception by the Minister of Education



## INTRODUCTION

The possibility of holding a series of science workshops in Colombia, similar to those sponsored by the National Academy of Sciences in Brazil, Peru, the Philippines, Nigeria, and Taiwan, was initially discussed in July 1967, when Dr. Harrison Brown, Foreign Secretary of the National Academy of Sciences, and Miss Theresa Téllez, Head of Latin American Affairs for the Academy, met in Bogotá with Ambassador Reynold Carlson, Mr. Harry Martin, Jr., Acting Director of the USAID Mission for Colombia, and other Embassy and USAID personnel. Subsequent talks were held with Minister of Education Gabriel Betancur, Minister of Agriculture Armando Samper, Dr. Edgar Gutiérrez, Director of the Administrative Department of Planning, as well as with scientists at some of the universities and members of the "MIT Club of Colombia" which included: Mr. Rodrigo Botero, Economic Adviser to President Lleras, Ing. Alberto Ospina, Director of the Foundation for Educational Development, and Dr. Oliverio Phillips, former Director of the Technological Research Institute.

All these persons emphasized the need to improve Colombia's scientific and technological capabilities. The Minister of Education offered to collaborate in the organization of a meeting of U.S. and Colombian scientists to discuss the problems and potential of science and technology in Colombia's economic development.

Ing. Alberto Ospina coordinated the arrangements for the Colombian participants, and in this connection was financially supported by

USAID to attend as an observer the U.S.-Brazil science workshop held in Washington, D. C., February 5-9, 1968. Miss Theresa Téllez coordinated the preparations for the National Academy of Sciences. Plans for the meeting were arranged with the assistance of Dr. Edward Schten, Adviser on Higher Education of the USAID Mission.

The workshop was held February 26 - March 1, 1968, in Fusagasugá, Colombia. Nine U.S. scientists and engineers selected by the National Academy of Sciences, and ten Colombian scientists and fifteen special guests, named by the Minister of Education, representing Colombian industry and government, met to consider: (1) the current state of scientific and technological research with respect to human, physical and financial resources in education, industry, agriculture and natural resources; (2) mechanisms to strengthen, organize and direct Colombian science toward the solution of the country's economic and social problems; (3) ways to create public awareness and interest in the role of science and technology in economic growth; and (4) possible plans for future collaborative action in the application of science and technology to Colombian development.

The Colombian participants prepared analyses of problems facing their country in the development of research. These reviews served as discussion papers at the plenary sessions of the workshop. They are contained in Volume II of this report, together with the contributions of the U.S. participants. Work groups formulated recommendations in the fields of education, industry, and agriculture and natural resources. A special working group elaborated a series of recommendations for a scientific and technological policy for Colombia.

This latter document was presented to President Carlos Lleras Restrepo on the occasion of the final session, held at the Presidential Palace at his invitation. President Lleras expressed a strong interest in supporting and facilitating implementation of the working recommendations and expressed his gratitude to the group, stating that the workshop marked the beginning in Colombia of a new concept in international cooperation.

A deep interest in applying professional competence to help solve Colombia's economic and social problems was expressed by a number of Colombians. It is recognized that this awareness needs to be made more widespread, in order to enlist the resources of the public and private sectors in what is viewed as a long-term endeavor. Although the meeting provided an overview of the present situation, it by means provided the time required to review in depth the problems of any one sector. It is therefore anticipated that means will be made available to continue these meetings in the future, to permit concentration on specific areas where the potential for development is considered greatest. In view of the high-level interest in this joint effort, and also the recent commitments made by the Colombian government to the OAS efforts aimed at strengthening science and technology, the outlook for scientific development in Colombia appears favorable.

Reports of the plenary sessions, the recommendations adopted, and other relevant papers, are contained in the following pages.

## SESSION I

Science Policy and Economic Development

The meeting opened with the following remarks by Minister Gabriel Betancur.

Distinguished Participants: The President of the Republic, Dr. Carlos Lleras Restrepo, sends you his very special greetings and his thanks for your participation in this Workshop on Science and Technology in Development, and hopes that the recommendations and conclusions arising from the workshop may assist the Government in giving a vigorous stimulus to scientific and technological development in Colombia. For many of us, interest in these disciplines was awakened perhaps only after we had left our childhood, but the President's case was different. His love of science was acquired in his own home, practically from the time he reached the age of reason, because his father, Professor Frederico Lleras Acosta, was one of Colombia's most distinguished scientists and dedicated his whole life to scientific research. The President has asked me to invite you, in his behalf, to the Colombian Presidential Palace next Friday for the closing ceremony of this workshop.

There is a pleasant coincidence in this work, because this is the first activity on science and technology in Latin America since the closing of the Inter-American Cultural Council, which met in Maracay, Venezuela on February 22. Allow me to inform you briefly of the results of the meeting, which gave such importance to the development of science and technology, in accordance with the mandates of the

American Presidents who met at Punta del Este in April of last year. The Council meeting was memorable because, aside from the select composition of the delegations, most of them were headed by their respective Ministers of Education. In all, there were more than 250 representatives. It is interesting to note that, for the first time, speeches by delegation heads were eliminated. Immediately following the inaugural session, the delegates began the intensive work which resulted in three instruments for improving the life and destiny of the American man.

First, in accordance with the dictates of the Buenos Aires Protocol, the Council was given a flexible organization which allows it to combine the interests of the different governments with the demands of technicians and experts in the fields of education, science and technology. For this purpose, the Council created a Special Commission and two technical committees responsible to the Commission. These committees will study projects presented by the governments, and make pertinent recommendations for their approval.

Secondly, following the guidelines set down by the American Presidents, the Council approved programs relating to science and technology, and education, indicating priority fields and establishing criteria for the selection of the projects presented by the governments. One example of responsibility was shown when the Council refused to approve certain projects because they lacked the necessary elements of judgment to assure their success.

Lastly, for the first time in the history of the Inter-American system, it created a Special Fund, which guarantees the Organization sufficient resources during the first year to finance projects which are approved. This fund, US\$25 million, of which \$15 million will be allotted to science and technology and \$10 million to education, was created during the last session, when the representatives of several countries offered contributions which now insure financing for more than 80 percent of this Fund. The United States, through Mr. Covey T. Oliver, Assistant Secretary for Latin American Affairs of the State Department, offered more than US\$16 million. Colombia was authorized by the President of the Republic to offer the sum of US\$387,500, corresponding to the OAS table of contributions.

In summary, the meeting of the Inter-American Cultural Council approved not only recommendations as to its structure, but also a balanced program, and created the financing necessary to make it a reality. April 15 is the deadline for the election of the Commission and its committees. All countries must present their candidates before April 1, in order for the OAS Council to hold elections. We expect that from April 15th on, when the commissions and committees are constituted, work will begin. We were well aware that there were two parameters in the discussion of the program: the first was speed, although speed was not to sacrifice quality. The important thing is to assure that the sectors in education, science and technology invest the allotted funds in the best way possible, just as

the economists have wished to invest the funds allotted for programs of economic development. This is even more important, since we have considered and proclaimed that the basis of all economic and social development is precisely reflected by the investments for education, science, and culture.

The workshop, therefore, is extremely important, because it is in keeping with the recommendations set forth in the Council by a group of national and international leaders in the field of science and technology. We, the organizers, hope that this workshop, upon completion of the agenda proposed, may offer the public and private sectors of the country precise suggestions for advancing the action President Lleras desires, of bringing science and technology to bear on Colombia's integral development plans.

This Government is realistic, and realizes the magnitude of what it desires to do. In certain sectors—for example, in agricultural research—the results are heartening. We realize that Colombia is in need of a policy for integrated, consistent and methodical development of its science and technology. Our overall development plan will bear more fruit when it is synchronized with a policy of scientific and technological development.

The formulation of this policy will include various sectors, some of which are considered in the papers presented at this workshop. This is not the time for me to discuss them, as they will be studied in detail later. The Government has studied the formulation of a policy in this area, but will not present it

here, because it wishes to allow the greatest possible freedom for each one of you to express your feelings. We request that you state all of your opinions with no restrictions whatsoever; that is why you have been invited as individuals; no one is representing any institution at all. We hope that you will contribute with your experience, to give us the benefit of your advice with complete freedom. We know that in addition to formulating a policy, the Government considers it indispensable to create instruments of execution and coordination. In a democratic country like Colombia, there are two large sectors in all these activities: the private and the public. The public sector must stimulate, motivate, create incentives and assist the private sector. At the same time, it must coordinate these two sectors, creating channels for this purpose, through which the sectors can reach agreement and advise the Government regarding modifications and additions to the policy for scientific and technological development. We know that the operation of an administrative policy and structure requires an additional indispensable element: the financial element. We wish to consider this aspect and would like the benefit of your experience. In a country like ours, with many needs and limited resources, it is imperative that priorities be determined very clearly in order to assure that efforts achieve maximum impact in all fields.

Government policy has one objective—to succeed. To this end it seeks the counsel of independent people who, like the Government, share the desire that the recommendations and conclusions of this

workshop provide the best basis for success for the country's endeavors. In a complex field such as science and technology, it is essential to plan with a great amount of realism. We are opposed to doing things rapidly and badly. We believe that once the inventory of Colombian science and technology is made, we will be able to draw conclusions that will constitute a solid basis for the permanent and vigorous utilization of science and technology in development.

I wish to thank the National Academy of Sciences of the United States for its interest and cooperation, given us from the very beginning when Dr. Harrison Brown visited Colombia some months ago and we discussed with him the Colombian Government's desire to formulate a policy and create the necessary mechanisms in the scientific and technological field. The idea of this workshop arose from these conversations. Our thanks go also to the Agency for International Development for its assistance in making this meeting a reality, and to all the foreign participants who have honored us with their presence and who will counsel us with their experience in determining the best roads to follow in this work, which the Government wishes to undertake with resolution and enthusiasm. We also wish to thank all of our countrymen who have cooperated with us in such a selfless and noble way so that this workshop might be successful. I want to emphasize the efficient collaboration received from Ing. Alberto Ospina and Dr. Oliverio Phillips in the organization of this meeting.

In closing, I wish to express my appreciation to the press for the importance it has given this workshop—proof of this is the group of photographers and reporters who have come here from Bogotá. It is the Government's desire that one important aim be included in formulating the objectives I have indicated: that Colombia be made aware that the only way to development is through a vigorous policy of promotion of science, technology and education. Any country which does not make this great effort will be permanently enrolled in the ranks of underdeveloped nations. The Colombian people have given this Government a mandate to raise it from the state of underdevelopment, and that is precisely what the President of the Republic is doing. We ask all of those in charge of news media to help us carry this message to the Colombian people. It is not only what we do here, nor what the Government can do, but the combined efforts of the entire population toward this national objective, that will make science and technology effective instruments for giving Colombians a better and more dignified way of life.

Dr. Brown summarized his paper\* entitled, "Science Policy and Economic Development," wherein he discussed the following questions: Why science and engineering? How many scientists? How many engineers? How much research and development? How much basic research? How large the growth rate? The importance of research and development to economic growth, and the need for local problem-solving competence were stressed. Dr. Brown concluded that if science and technology are to grow in the less-developed countries at rates commensurate with their growing needs, it is essential that governments establish policies and mechanisms which will provide for adequate scientific-technological advice at the highest levels. In his opinion, any governmental mechanism adopted should provide for the following:

- a) Advice at the highest levels of government concerning problems and opportunities involving scientific-technological development;
- b) The means whereby science and technological change can be adequately taken into account in national economic planning;
- c) Mechanisms that will enable each government agency to undertake or sponsor research which is relevant to its mission;
- d) Mechanisms that will ensure that industrial research of importance to the national economy will be undertaken either within the private sector or by the government-operated laboratories established for the purpose;
- e) Means for insuring that the results of applied research are used to improve the effectiveness of operations and the efficiency of production in the various sectors of the economy;
- f) Means which will enable adequate government funds to be channeled selectively to scientists in the universities for the support of their research activities, both basic and applied, on a continuing basis;
- g) Establishment of post-graduate education in all areas of science and engineering relevant to national economic and social development;

\*The full text is contained in Volume II of this report.

h) Strengthening of science and engineering education in the universities, at the undergraduate level;

i) Development of adequate curricular and teaching methods in science and mathematics in the primary and secondary schools;

j) Means that will ensure that the limited resources available are allocated to these various activities on a national basis, and that will enable the multiplicity of efforts to be coordinated; and

k) Mechanisms which will enable the non-governmental scientific-engineering community to criticize government programs constructively and advise the government about needs and opportunities in research and education.

In subsequent discussion, it was suggested that methods be developed to reduce the period of time required to reach the scientific levels referred to by Dr. Brown. The possibility of utilizing foreign personnel from the United States, Japan, and Germany was mentioned. In addition, maximum advantage should be taken of Colombian scientists working abroad. Dr. Betancur mentioned that ICETEX is organizing a seminar on ways to encourage the return of Colombian scientists. This seminar might study the basic conditions required to achieve this.

In training engineers, Colombian universities should take care to maintain quality, while increasing numbers. There must be a correspondence between the demand for professionals, and the supply, through the higher education system. There should also be direct communication between universities and the community in order to develop job opportunities for specialized personnel. It was pointed out, however, that the demand for highly-qualified personnel cannot always be determined through direct inquiry to potential employers, because private enterprises frequently cannot estimate what their needs are going to be in the future. This point was cited in stressing the necessity of promoting research through national planning programs.

Some industrial areas develop slowly because of the numerous small units which comprise them, as for example, in agriculture. This sector therefore requires governmental action to promote its development through science and technology. Areas of high economic capacity, which can support research without affecting their financial situation, should be left to their own initiative.

Mr. Wilson cited a number of case histories relating science to development. He suggested that support of science and technology does not automatically insure development. In his view, science and technology do not stimulate development, but respond to it. The central, most important factor in development is the scale, composition, and employment of high-level manpower. There are severe limitations on what non-nationals can contribute to a society; hence, the national educational system is of great importance, as is the ability of the society to absorb and effectively utilize its trained manpower.

Mr. Wilson commented on his work with Western European countries since 1960, in the development of policies for science and technology. During recent years the Organisation for Economic Cooperation and Development (OECD) has reviewed and examined national education systems for science and technology, and this has been valuable for many countries. As a result of the belief that the learning process itself needs much study, a new Institute for Educational Innovation has been created within OECD.

OECD also has a program for the review of national science policies. The Japanese policy is especially interesting, in view of

Japan's great success in exploiting world knowledge of science and technology for its own development. The review of United States science policy revealed that the country has not had a clearly-defined national policy. A difficulty in many countries has been the absence of a well-defined governmental entity to make decisions on national science policy. Colombia is not alone in the lack of a well-developed and articulated policy for science and technology.

In discussing the technology gap between the United States and western Europe, Mr. Wilson observed that science in Europe is of very high quality. There is a sharp difference in the attitudes in Europe and the United States with respect to industrial research. In the United States, companies believe they can make anything they can sell; whereas in Europe, industry believes it can sell anything it can make. In the United States there is better cooperation between industry and government. In the U.S. industry, the sense of urgency for applied science, and the intensity of competition, are much greater than in Europe.

A nation can invest large sums in science and technology with little effort on economic development. The result may be merely the growth of a cosmopolitan scientific elite, or a disillusioned brain drain.

A specific strategy for science and technology is necessary. National planners must concentrate resources on specific targets within the national development plan. Technological inputs, and their timing, must be assessed for each specific target. After the scientific and technological needs have been identified, there

must be careful analysis of the means to obtain them. Inventories of obstacles, bottlenecks, and needed incentives must be made. Mr. Wilson stressed that individual initiative is what makes things happen.

In summary, there must be a national plan for development, a related science and technology plan, and a system for evaluating accomplishments. Mr. Wilson cited the example of recent agricultural development in Turkey as a useful model.

## SESSION II

The Need for a Colombian Policy for Science and Technology

Dr. Gabriel Betancur stated that a policy for science and technology must be related to and coordinated with the nation's economic development plan. Priorities must be established in both the economic and technological spheres to assure maximum use of resources. Unnecessary duplication of research effort must be avoided, to assure optimum use of financial resources. Coordination between the public and private sectors is necessary to achieve the greatest progress.

Dr. Betancur agreed with previous statements that good administration is important. Adequate educational opportunities must be provided at all levels, not at the highest levels only. National development plans must take into account the creation of jobs necessary to utilize the output of an improved educational system.

He also agreed that research is a good investment deserving support by all sectors of the nation and of external financial assistance. He suggested that an institution comparable to the National Planning Office be created, to design policy for science and technology and to establish priorities. A decision would need to be made on whether such an institution would be advisory only, or have executive responsibility for implementing an approved policy.

Dr. Piñeros noted that the Colegio Máximo de las Academias y el Patronato de Artes y Ciencias have urged the Government to create such an organization and pledge their full support. He emphasized the need for anthropological and social sciences research, in order to identify the Colombian man and his life more scientifically. He pointed out

that at one time Colombian research had served as a model for other Latin American countries, and that Colombia had excelled in philosophy.

Dr. Young urged the establishment of a Department of Science and Technology at the level of the National Planning Office, whose directors would be selected on purely scientific criteria, and which would report directly to the President of Colombia. This department would develop policy, coordinate research, and administer funds, but it would not operate its own research establishment. Dr. Young felt an unusual opportunity for creative action exists, and that Colombia should not be timid about establishing a mechanism for scientific and technological planning in support of the National Economic Development Plan.

Ing. Ospina emphasized the need for the Government to commit funds, create incentives for private investment, and offer official backing for the research and findings of scientists and engineers.

Mr. Toro discussed the dynamic contribution of scientific resources to economic development, citing a comment that "capital lies between science and technology." He suggested that in selecting priorities preference might be given to areas related to human biological deterioration, such as nutrition and agriculture, education, and transportation. Consideration must also be given to electrification, ports, internal communication, industrialization, defense, and the utilization of natural resources. He felt that financing for this research is possible, provided the projects are concrete and scientifically sound. He suggested that the science and technology planning body be established with the National Planning Office, since the latter has basic information necessary to relate planning for

science and technology to the national economic development plan.

Dr. Brothers emphasized the need for continuing the dialogue between economic planners and scientists and engineers, to assure effective application of the results of science and technology to the country's economic and social development. He pointed out that much of the technology of developed countries is prejudicial when applied in the developing countries, because it has been developed on the basis of a shortage of human labor and an abundance of capital; whereas technology in developing countries must be concerned with the reverse situation.

Dr. Phillips spoke of the need to motivate young talent towards science and technology, and the private sector toward the utilization of research and technology. He stressed the importance of having a group of "brains" thinking always in the future, without the limitations of government, which is forced to give its attention to the present.

Dr. Botero stated that the government has not ignored research. It has provided resources to the proper sectors, for example, the universities. The problem is more one of coordination than of creation. The dialogue between economists and scientists, already mentioned, is essential for development.

Drs. Brown and Djerassi cited examples of developments in Taiwan and Brazil which might serve as thought-provoking models for study by Colombians.

It was agreed that environmental and working conditions conducive to the encouragement of research must be given high priority.

Current Educational Research in Colombia

The panel, consisting of Drs. Céspedes, Ruffat, and Arias, stated that research in teaching methods, curriculum development, educational administration, environmental background and characteristics of the students, student motivation, and evaluation of educational results is of significant importance today. Examples of research by faculty members at the Universities of Antioquia and del Valle, with student involvement, which has produced useful information without excessive costs, were cited. The panelists expressed concern that the lack of means to communicate the results of this research, and to disseminate information from abroad, constitutes a major obstacle to progress. They urged that resources be allocated for low and middle level (technical) training, as well as for graduate training and programs.

Drs. Brown and Djerassi felt that Colombia cannot progress as rapidly as is desired and necessary, if it tries to improve education at all levels simultaneously. They urged early and substantial efforts at the highest level, since highly-trained graduates will train college teachers, who will train secondary teachers, and so on. They urged early identification of promising students who might be trained in a specialized secondary school, in order to achieve maximum progress in the shortest possible time. In this connection, experience of this type in Turkey and the U.S.S.R. was cited.

Dr. Betancur said that justice might be kept in mind. The people are justifiably demanding an education now, and cannot wait

until more graduates are available for the system. It is evident that the present systems are inefficient; and the question is, therefore, which systems are the right ones. Certain facts are clear. For example, the Ministry has no mechanism for disseminating its policies or its research. This situation will be remedied immediately. However, it is clear that periodical publication will not be sufficient to solve the problems of education, culture, science and technology.

A number of the participants questioned an undue concentration on high-level education, urging attention to all levels. Particular mention was made of the need for improvement at the middle level in both quality and quantity of graduates.

## SESSION III

Technological Problems in Agricultural Development

Dr. Guerra discussed the technological problems of agriculture as outlined in a paper prepared by Minister of Agriculture Enrique Blair. The problems can be divided into four categories: (1) research, (2) production, (3) extension, and (4) mechanization and capital services. The most striking gap in research is the failure to study the ecology and agricultural potential of the country's hot, humid tropics which represent 83 percent of the total area and 40 percent of the population. The importance of these zones lies in the potential for production of exportable items (e.g., cotton, bananas, cattle) and import substitutes (cacao, sesame, palm oil). Rain, temperature and sunlight conditions favor a greater production efficiency in these areas than in Colombia's temperate and cold zones.

Only limited attention has been given to the important area of processing and marketing (about one percent of the total investment in agriculture, in terms of personnel and budget). Problems relating to fertilizers, equipment, etc., are due principally to their high import content, the poor market structure, and the low quality of some products.

Problems relating to agricultural extension can be summarized as follows: insufficient and inadequately-trained personnel (it is estimated that only one-sixth of the farm land can be reached), and lack of coordination among the various agencies and organizations. There is little adoption of new technology and mechanization, although where intensive use of machinery has occurred, the result has been a lower demand for labor.

The solutions suggested by Minister Blair include the following.

- a) the transfer of resources and the adaptation of research from the temperate zones to the humid tropics;
- b) additional research on processing and marketing, proportionate to the economic importance of the tropical area;
- c) increased use of domestic fertilizers and of additional imported machinery for agriculture and agricultural-related industries;
- d) the establishment of state enterprises or farmers organizations which would encourage more competition on the domestic market;
- e) the improvement of dissemination of information through agricultural extension; the utilization of young farmers and leaders, better coordination and planning among state agencies; and intensified teaching of social sciences and rural administration in agricultural schools;
- f) Other improvements include changes in land tenure and price policy to encourage farmers to adopt new technology and to increase production.
- g) Finally, to avoid campesino unemployment, mechanization should be limited mainly to opening new areas.

Dr. Cardona began his presentation by referring to the research and technology revolution which began in 1942, aimed at increasing basic food production. The Rockefeller Foundation program, initiated in 1950, resulted in the creation of the Colombian Agricultural and Livestock Institute (ICA), which combines research, education, and extension functions within a single but administratively decentralized agency. ICA programs, conducted in Centers and stations throughout Colombia's major ecological zones, have concentrated on developing hybrids and better basic food crop varieties. These varieties now produce 25 percent more than native varieties under normal conditions. The total agricultural research investment between 1950 and 1967 (278 million pesos) is about the same as the amount by which the 1966 crop value exceeds the value it would have had without these crop improvements.

Dr. Cardona mentioned that ICA cooperates with twenty public and fifty private organizations, as well as with thirteen international bodies. He believes ICA's success is largely due to international cooperation, which made possible the availability of high-yielding seeds, and the creation of a nucleus of highly-qualified researchers.

According to Dr. Cardona, the two most important problems concern the present extension system in that very few farmers make use of the results of ICA research, and the low-level education of farm administrators results in extensive damage to machinery and imported products.

Dr. Young observed that although extensive crop research is of great value, attention to the neglected field of agricultural industry would result in better utilization of increased production, new industries offering increased employment opportunities, improved nutrition, avoidance of crop waste, import substitution, and even new export products.

Dr. Betancur emphasized that the low level of education, and the illiteracy of the rural population is the root of the problem of transmitting research results.

Mr. Wilson inquired about hectare yields, market price, and disease resistance of Opaque-2 corn as compared to conventional corn, and about the INAGRARIO project to increase storage capacity and reduce price fluctuation, which was to be established to enable the farmer to make a greater profit, thus increasing his incentive to improve yields. Dr. Cardona explained that Opaque-2 is too new to make any conclusions. There is no data on disease, and the price of corn is generally less prone to fluctuation. On the whole, however, the problems are comparable—

including the limitations to those in the Cauca Valley. With reference to the second point, INAGRARIO and the banks are conducting a campaign to increase the country's storage capacity. It is estimated that effective price support requires storage capacity for 20 percent of the crop production; however, this is not available at present.

Dr. Cardona replied affirmatively to the question "Could ICA effectively double its budget?", adding that first priority would be the training of intermediate-level personnel to take existing technology to the farmer. In answer to an inquiry on whether increased yields would find ready markets, Dr. Cardona said that although the situation would vary from crop to crop, he expects no difficulties in the foreseeable future if the general economic situation (wages and incomes, in general) provides a market.

#### Non-Renewable Natural Resources

Dr. Suescún's presentation was divided into two parts: a general characterization of minerals as abundant, adequate, or scarce, and a discussion of problems facing the mining sector. According to Dr. Suescún, limestone and marble are abundant throughout Colombia. Limestone is mined by thirteen cement plants, which produce about two million tons a year of Portland cement, as well as calcium carbide, white cement, and lime. Limestone rock is not mined extensively, although the reserves are virtually unlimited. Production is low, averaging about three million tons per year.

Recently, the Mineral Resources Survey, in collaboration with the

U.S. Geological Survey, found extensive and rich deposits of phosphate rock along the entire eastern cordillera of the Colombian Andes. Building materials such as foundation stones, graded materials, materials for concrete aggregates, sandstone, sand, schist, and serpentine are abundant.

Also available in sufficient quantities are petroleum, natural gas, nickel ore, gold, silver, platinum, sulphides of copper, lead and zinc, kaolin, feldspars, and emeralds. Iron, chrysolithic asbestos, gypsum and manganese are scarce, although detailed exploration for these materials has not been made.

Dr. Suescún outlined the following problems:

a) There is a great lack of coordination and overlapping among the different government agencies, aggravated by unilateral and contradictory criteria which distort the development process. A coordinating committee at the presidential level is required to remedy this situation.

b) Mining legislation is obsolete. For example, the government receives only 3.5 percent in royalties from the petroleum operations at Putumayo. A review and up-dating of mining legislation is urgently required.

c) There is a lack of capital for mineral development. The creation of a mining bank, analogous to those for agriculture and industry, is suggested.

d) There is a lack of technically-qualified manpower in the area of geology, mining, and utilization of minerals. It was pointed out that the United States has approximately 1500 geologists per million square kilometers. Colombia has only 250 for the entire country. It is not surprising that between 1939 and 1968 only 10 percent of the country was surveyed.

#### Problems in the Development of Research

Dr. Zethelius pointed out that accumulated knowledge is more important than a country's capital and equipment. The most profitable investment is in education. There is a widening gap between the developed countries

and the less-developed countries, which have been bypassed by new technology, and have little to offer in exchange for the acquisition of technology. Science must be applied specifically to tropical conditions, in order to establish some kind of equilibrium. The imbalance in technological advance coincides with the "revolution of rising expectations." The development of "tropical science" is a condition for social progress. It is futile to attempt to reach the level of the developed countries in all respects. Their backgrounds, conditions, and perhaps even objectives are significantly different.

When we turn inward, the vision of the future is quite different. Because of the rapid obsolescence of traditional science and technology, the less-developed countries are in a position to "start from scratch," i.e., to develop on the basis of contemporary science and perhaps in time, overtake the developed countries. Moreover, today's tropics have a changing aspect. There is, above all, the great resource of solar energy which is converted into millions of known and yet-to-be-known products. Efficiency in this process is very high in the tropics. Cultural heritage has caused the neglect of indigenous advantages. The resources of the tropics, even without new science, are more than sufficient for developing prosperous communities. Some examples are:

- 1) Solvent extraction of metals, eliminating current cumbersome processes. Fluid leaching has already been exploited in Mexico for iron ore, and other Latin American countries are ready to cooperate.

- 2) The lack of knowledge on local flora is incredible, the potential very great. One need only mention the Mexican experience in synthesis of hormones from native plants. Colombia imports wheat, and fails to develop its own native plants, such as yucca and others, even though the technology to modify flavor, texture, appearance, and so on, exists.

3) Likewise, the products of the sea are wasted. Peru's success in fish meal production is an example of what can be done. The technology of raising micro-organisms is well-known.

There are three principal obstacles to the needed research: lack of personnel; lack of equipment; and lack of motivation and research environment. Of these, the lack of manpower is the most difficult to resolve. In the long run this can be remedied through a great increase in postgraduate study and the training of Colombians abroad. But for the immediate future, better utilization of available manpower is required. Toward this end it is suggested that all agencies—academic and industrial—contribute to the national research effort. Secondly, industries which do not conduct research should obtain help from the universities. Finally, highly-skilled people in universities and research organizations should be freed of mechanical and clerical duties, thus raising their research contribution by many thousands of hours. In addition, they should be provided with more assistance from intermediate-level personnel.

Greater collaboration between industry and the university would not require any significant bureaucratic structure at the national or local level, but would be an enormous factor in spurring research. This has already happened in many universities. What is needed is to turn this collaboration into a national program.

Dr. Tobón said that although it is not now possible for local universities to train scientists to the extent possible at the international level, there are disadvantages to sending scientists abroad for their training. The orientation and viewpoints acquired abroad do not correspond to the needs of Colombia, where less specialization and more flexibility are required.

Dr. Tobón mentioned the following points regarding the establishment of graduate studies in Colombian universities: (a) in contrast to education abroad, local training would be directed toward Colombia's problems, and scientists could be produced in greater numbers; (b) needed research facilities would be provided, thus improving the efficiency of research; and (c) since the cost of postgraduate training exceeds that of undergraduate education, larger funds must be appropriated for universities, to prevent a lowering of the quality of undergraduate studies.

Dr. Tobón warned against concentrating research activities in a few institutions only. This would prevent universities from combining the functions of research and training, and would reduce the professor to a mere transmitter of information, incapable of infusing his students with an interest and attitude for research.

Inadequate libraries are an additional obstacle to research. A remedy would be inter-library exchange.

Dr. Tobón recommended the following:

- 1) Creation of a national fund to support scientific research and technology. This fund would provide research grants, support for libraries, funds for data collection, and finance professional meetings.
- 2) Removal of customs duties on scientific material and equipment imported into the country.
- 3) A continuing study of the collaboration between SENA and the universities in the training of medium-level personnel, in order to take advantage of the universities' teaching experience and SENA's basic resources and finances.

In the discussion which followed, the need for data centers for research was strongly emphasized. Cooperation between universities and

industry in the support of scientific and technological programs was also strongly recommended.

It was stressed that research efforts should be directed toward the country's problems, and its potential. For example, research should be conducted on coal—one of the country's great natural resources—as a raw material for the chemical industry, or as fuel for electric power.

Dr. Cain suggested that the "demonstration" method, in which community leaders are persuaded to institute innovations on their farms, would be effective in getting campesinos to apply known technology.

Dr. Waugh pointed out that current low agricultural production should not be criticized. ICA has been engaged in a long tooling-up period. Even on the basis of inadequate data, it is obvious there have been some significant increases in production, although no signs of a breakthrough are yet evident. An "esprit de corps" is necessary for success in involving effective people.

Mr. Wilson felt farmers would be willing to take risks if they could foresee a large gain from which they would benefit. However, Dr. Waggoner pointed out that subsistence farmers cannot afford even a small loss. They must be assured they won't starve, if the innovation results in crop failure.

Dr. Brown referred to success in improving the population's nutritional level in other countries. He cited the Hong Kong experience where a bottled drink based on soybeans, providing 16 grams of balanced protein per bottle, now outsells Coca Cola. This is the fruit of cooperation between industry and academic research.

Dr. Djerassi remarked that the workshop participants appeared to be in agreement on generalities, but not on their application to Colombia. He was interested in showing that under certain conditions, a less-developed country can engage in both basic and applied research—it is not an either/or question. Dr. Djerassi defined a technician as a man who applies science to local circumstances, and a scientist as one who develops new knowledge applicable anywhere. He cited a successful experiment in Mexico to illustrate the possibility of shortcuts to basic research in less-developed countries. The project was based on local development of cortisone from native plants, and it attracted young Mexican and foreign scholars. The abundant theoretical work became associated with the highly-profitable venture and subsequently this knowledge was utilized in other scientific fields. A basic protective device was the prohibition placed on exporting the native plant. This began when there were only two chemistry Ph.D.'s in the country.

While there is no way to duplicate all the favorable circumstances which were present in the case cited, Dr. Djerassi pointed out the Mexican experience might point the way to certain principles of organization to which he intended to return at a later point in the workshop. He mentioned that the idea is fully developed in the January 1968 issue of the Bulletin of the Atomic Scientists.

#### Advanced Technological Approaches to Education

On Tuesday evening the participants had occasion to hear Dr. William Bollay, who made a special stopover enroute to his home in California, in order to speak on "The Use of Communication Satellites for

the Relay of Industrial TV Programs."

Dr. Bollay believes that the current state of the art of space technology makes it technically feasible to provide communication satellites which can bring as many as three educational TV programs direct to any village school over an area as large as Brazil. A similar satellite, radiating over a smaller area of Colombia, Peru, Venezuela, Ecuador, and Bolivia could simultaneously provide three direct TV programs and in addition provide 9,000 telephone channels for regional communications.

Recent studies carried out during a graduate course at Stanford University concluded that such a communication satellite could provide a low-cost solution to the problem of making the best teachers in a region available to all of the schools in the area. In Brazil, the cost of such a communication satellite system would amount to about 20 million dollars per year over a period of ten years. This amounts to a cost of about \$100 per school year or about one dollar per student per year. If two TV receivers are allocated per school, to allow for possible malfunctions, the cost would still be less than two dollars per student per year. These costs include the cost of the satellite system, as well as ground receivers, programming, and follow-up services with the schools.

It is suggested that if such regional satellite systems combined the educational TV relay with the additional function of interconnecting regional telephone systems, the savings in the communication function (over the use of microwave links) would pay for the complete educational TV system.

An evaluation of more than 400 instructional TV projects, extending from primary school through university, has shown that instruction via TV is about equally effective as having the same teachers present their lessons directly in the class room. A local teacher will be required in each class room anyway; however, the quality of the instruction, particularly in the sciences, would be greatly improved over what the local teacher would be able to provide without the use of TV. The pace of improving education would be much more rapid and less costly than attempting a massive retraining program of the teachers without the use of TV.

## SESSION IV

Technological Problems in Industrial Development

Dr. Poveda stated that the most critical ailments of technological research in Colombia are that it is sporadic, disperse, and uncoordinated, lacking both governmental and industrial support.

Professional researchers account for less than 0.1 percent of industrial personnel. There is no high-level research, and many scientists and technicians are not working in their fields of specialization. Foreign technology has been introduced indiscriminately, frequently at very high cost for trivial processes. The Technological Research Institute and ICONTEC have lacked adequate support, and the universities are detached from industrial problems. Vital international exchange of information is severely limited. It is extremely difficult to obtain data on research and processes of great importance to industrial development.

Dr. Poveda cited limited domestic markets, insufficient capital, and poor technology as three major constraints on industrialization. Industrial development is lagging far behind the goals of the National Development Plan, although industry's contribution to the GNP should be from seven to eight percent. Since 1960, it has reached only two to three percent.

Precarious development threatens employment. Dependence on imported materials for industry deters normal development. Although Colombia should be exporting products, utilizing extensive manual labor, the great majority of products exported for the world market are those employing a minimum of hand labor. Goods requiring a high percentage of hand

labor must meet standards of quality, efficiency and safety which Colombian industry cannot meet. There is great profit potential in a scientific and technological program to develop industrial processes and equipment employing the national labor force, e.g., ceramics, confections, leather, rubber. Textiles and cements are examples of national industries which have succeeded in employing international technology and national resources, and are now exporting their products.

Dr. Poveda recommended efforts to reduce dependence on foreign technology; however, this presupposes an adequate assimilation of foreign technology, and the encouragement of Colombian research. This would reduce the costs of patents and royalties. He also alluded to the necessity of the exchange of information on research being done in Colombian institutions, and the need for cooperative programs between the universities and industry. According to Dr. Poveda, a common market of science and technology is of utmost importance to Latin America. This interchange has not received the attention it deserves.

Dr. Uribe attributed the lack of industrial research and development activity to deficiencies in the educational system, and urged cooperation between the government, the private sector, and the universities in solving this problem. He cited the inadequacy of human resources, and the need for scientists and engineers to enjoy a higher status in Colombian society, as basic factors. He also suggested revisions in labor legislation, to facilitate regional industrialization. He pointed out the importance of LAFTA to Colombian industry, in that it helps compensate for the limited domestic market.

Dr. Carvajal stated that Colombian industry has already passed the stage of dependency on imported technology. The next phase has begun but modern production processes require thinking in terms of international markets. He agreed on the need to accord greater recognition and respect to the country's professional talent, who now go abroad to find satisfaction. It is necessary to create a favorable public opinion concerning the need to advance technologically through continuing studies, especially in the field of management.

Dr. Djerassi argued that Colombia need not suffer disadvantages under the international patent system, if proper national laws are enacted. He feels that potential researchers should become interested in industrial problems during their years of training.

Dr. Marulanda spoke of the problems of low salary and status of university faculty and cited these as causes for the limited research carried out in universities. He also spoke of the difficulty of repatriating Colombian scientists living abroad. Dr. Marulanda mentioned President Lleras' desire that universities participate more actively in research programs.

Dr. Brown suggested that attention should be given to natural resources which have industrial possibilities, to determine where advanced technology might be applied profitably. He referred to Brazilian efforts to encourage industrial research and development efforts.

Mr. Landsberg observed that economic parameters and priorities were not being given sufficient attention in the discussion. He also emphasized the need to relate industrial research and development

activities to objectives of the national economic development plan.

Dr. Manrique referred to the danger of industrial raiding of university professors.

Dr. Martínez suggested that the work groups consider the following recommendations: (a) ichthyological research on continental shelf regions, through modern techniques; (b) study of natural resources with export potential; and (c) revision of university rules governing relationships between academic degrees and faculty rank.

Dr. Folkers described the role and activities of the Stanford Research Institute, and proposed the creation of a similar institution in Colombia. (The text of the proposal is contained in Volume II.)

## SESSION V

Discussion of Work Group Reports and Approval of Recommendations

The reports and recommendations of the working groups were considered during the final day of sessions, in the following order: Education, Industry, Agriculture and Natural Resources, and Scientific and Technological Policy. Recommendations which required revision were returned to the respective working groups for additional study, were then reconsidered by the participants, and were finally approved at the last plenary session. The approved recommendations appear on page 41.

Dr. Luis Ospina, a special guest, asked to have his reservations recorded on the science policy recommendations, which he felt were oriented too exclusively toward the natural sciences and technology, and had omitted the social sciences. There was a brief discussion and it was agreed the social sciences should be taken into account, more specifically in the science policy, even though their inclusion was already implied in the study called for. Because it was felt that the social sciences required more attention and study, Dr. Betancur proposed the following recommendation, which was unanimously approved.

In view of the results of this meeting, the participants of the Colombia-U.S. Workshop on Science and Technology in Development recommend that its organizers consider holding other workshops to expand and continue the work initiated. It is suggested that a workshop on the contribution of the social and administrative sciences to development would be appropriate and useful.

## SESSION VI

Closing Session

At the invitation of Dr. Carlos Lleras Restrepo, President of Colombia, the closing session was held at the San Carlos Palace in Bogotá on Friday morning. Members of the President's cabinet and several guests were present, including Ambassador Reynold Carlson and Minister Marvin Weissman from the U. S. Embassy.

The document containing the recommendations on a national science policy was read by Ing. Alberto Ospina. Minister Betancur commented on the diligent work of the participants, emphasizing the productiveness of the workshop at Fusagasugá. He was particularly generous in his praise of the contributions of the U. S. scientists. He stated that scientists attach great significance to the struggle for freedom, and recalled the distinguished Colombian scientist of the Nineteenth Century, Celestino Mutis, whose botanical expeditions contributed so greatly to the discovery of Colombia. He added that the vital transformation of the country today will depend in great measure upon the application of science and technology in helping to eliminate hunger, misery and ignorance.

Dr. Brown's remarks in response were as follows.

Mr. President, Minister Betancur, ladies and gentlemen,

On behalf of the National Academy of Sciences of the United States of America, and of my colleagues from the United States who participated in this seminar, I want to thank our colleagues from Colombia for their warm hospitality and to express our admiration for the dedicated Colombian efforts which made this seminar such a success.

I also would like to take this opportunity to emphasize the serious concern with which the scientific-engineering community in my country views the critical situation in the world today with respect to the

widening economic gaps between the rich countries and the poor, to the increasing severity of the world food problem and to the slowness with which misery and deprivation are being eliminated from the world scene.

I am constantly impressed by two characteristics which members of the scientific-technological community the world over have in common. First, we recognize that science and technology, properly applied, make widespread hunger and poverty in the world inexcusable. We know that science and technology can help create a world in which hunger and poverty can be eliminated. Secondly, members of the scientific community are able to communicate with each other, in spite of national boundaries, in spite of differences of culture.

During the past week, natural and social scientists and engineers from Colombia and the United States have been living together and discussing in detail these problems of mutual interest, with particular reference to the problems of Colombia. We have concluded that science and technology, properly planned and mobilized, has an enormous role to play in the development of this beautiful country, which is filled with such tremendous potential wealth.

Mr. President, we are impressed by the vitality of your scientists and by their eagerness to play a major role in development. It is our hope that you give them the opportunity of doing so by creating the appropriate governmental mechanisms

I can assure you, Mr. President, Mr. Minister, and our good Colombian friends and colleagues, that the members of the scientific-technological community of the United States stand ready to work with you in the months and years ahead in joint efforts to study and solve these critical problems of mutual concern.

President Lleras expressed appreciation for the participation of national and foreign scientists and for the assistance provided by AID and the National Academy of Sciences. He commented that the workshop meeting was most useful to him because of the complete and valuable recommendations which were formulated. These are to be published for the general public and made available to appropriate entities. The President promised the creation of a committee which will be charged with the study of an appropriate governmental mechanism for implementing the recommendation concerning the development of

a science policy.

The President made note of the following areas which he considers merit special study: (1) the availability of human resources; (2) creation of research centers which would also attract foreign technology; and (3) the means to disseminate research results as well as to adapt foreign research. Universities were cited as important elements in developing the environment for scientific research, and in complementing the efforts of private research centers.

The President expressed his regret at being unable to attend the workshop. He concluded his remarks by saying the meeting constituted a significant starting point for calling attention to the importance of science and technology in the development of Colombia, and in closing the gap between the various social and economic levels.

## RECOMMENDATIONS

### I. EDUCATION

It is recommended that -

1. The training of science professors for all levels be increased rapidly in the universities, and that aid be given to organizations involved in improving the preparation of professors currently teaching. In particular, it is necessary to take measures to increase salaries of college graduates teaching in secondary schools and to see to it that it is compulsory, within a reasonable period of time, for science teachers to hold at least a bachelor's degree, in order for these schools to be approved.

2. Encouragement be given to universities and other institutions that are duly qualified to conduct socio-educational and psycho-pedagogic research intended to develop the best systems of science teaching in the primary and secondary schools, and to create an environment that will help in the development of scientific and research interest from pre-school age onward. Along these lines, attention should be given to the strengthening of public high school and college libraries, the creation of museums, the production of adequate texts and the holding of science competitions and fairs.

3. Universities encourage research on the part of their faculty. Equal importance should be given to time devoted to research and time devoted to teaching (classroom lectures, guidance, student consultation, etc.), and recognition should be given to published research in determining the tenure and promotion of university instructors.

Universities should be advised to encourage full-time professors to accept paid consulting assignments in both government and industry when these consultations do not interfere with their university work and responsibilities. In general, these consulting activities should not exceed an average of one day per week.

Industry and research institutes should encourage their scientific and technical personnel to engage in teaching and research in the universities.

4. A policy be established whereby the National Fund for Research would support research projects which have the following two characteristics:

- a. The scientific level of the work is comparable with that of the international scientific community; and

- b. The research problem, in a high percentage of cases, is relevant to Colombian development.

5. Research programs be developed in collaboration with universities or similar institutions in other countries. The conditions for such projects might vary greatly, depending upon the circumstances and the participants in each program.

6. A wage policy be established for university professors and high-level researchers at institutes, particularly in the basic sciences, which would be in keeping with the academic dignity of these positions and their usefulness to the country. Salary levels should be competitive with those in the private sector.

7. In selected areas of science and technology, initially in the basic sciences and then expanding into engineering and the applied sciences, special efforts must be made to develop graduate studies and research in a limited number of universities. A variety of mechanism for encouraging the return of distinguished Colombian scientists and engineers now residing abroad should be studied and the most promising of these should be implemented. Although the majority of these individuals, might want to return to Colombia, perhaps due to patriotic and family sentiment, the very important need for creating a stimulating atmosphere in Colombia should not be overlooked. This means higher salaries, well-equipped laboratories, well-trained assistants in sufficient numbers, library facilities comparable to those at research institutions in other countries, computer facilities, support for travel to international conferences, and so on. It would be expected that persons involved in graduate-level teaching and in research at the highest levels would interact with students and professors on all levels within the universities, so that a more stimulating atmosphere might prevail in the entire institution.

8. The proliferation of universities be slowed down because of the harm done to higher education, especially considering the tremendous shortage of qualified personnel. Accreditation systems should be established which would be independent of the institutions and which would be reviewed periodically. Accreditation should take into account the quality of the teaching personnel, minimum admission requirements for students, equipment, working conditions for the faculty, incentives for research, etc. Accreditation systems are especially important regarding graduate studies, which ought to be established in the country before there is a proliferation of this type of program.

9. Since the capacity to carry out high-level scientific and technological research programs is essential to the success of graduate studies on the doctorate level, it is recommended that the National University Fund, in cooperation with the National Planning Department

and other corresponding agencies, set up an ad hoc committee consisting of Colombian scientists and, when necessary, supplemented by foreign experts, who would identify the most urgent areas of research in the interest of the country's development. This committee should take the following aspects into account:

- a. In general, programs should not require unusually high expenditures;
- b. The research effort should offer hope of leading to an eventual long-term technological development;
- c. The utilization of local circumstances which may facilitate this research effort in Colombia; for example, local plants, minerals, marine resources, etc.;
- d. The fields should be active ones in which there is a substantial international reservoir of trained scientists at the doctoral level in order to make the initial staffing possible.

10. While initial steps are taken toward the establishment of doctoral studies, new programs should be established at the masters level, and the existing ones should be expanded for the purpose of increasing the human resources necessary for undergraduate education and for training middle-level teachers. This scheme should be continued until there is a sufficient number of professors at the doctoral level engaged in teaching graduates and undergraduates, and also engaged in conducting research.

11. Special attention be devoted to the study of the humanities and social sciences, as well as to research in these fields. In the exploration and utilization of the country's resources, it must be kept in mind that man is the primary resource, and the success of many scientific and technological projects will depend upon knowledge of the social environment in which and for which they are being developed.

12. That an official Scientific Research Fund be created which would receive initially from the government no less than 0.2 percent of the gross national product until it reaches no less than one percent over the next ten years. It is furthermore recommended that individuals be authorized to deduct from their taxable income double the amount contributed to government-approved universities for research programs sponsored by the Scientific Research Fund.

13. The national government take measures to facilitate the importacion of scientific literature (books and journals) without

prior license, and to permit easy acquisition of the foreign currency required for its importation. In addition to making funds available for importing scientific equipment, the Government should facilitate customs exemptions and rapid handling of such equipment through customs. Special attention should also be devoted to rapid customs processing of spare parts and replacements, to eliminate the currently deplorable situation wherein expensive scientific equipment stands idle for long periods of time due to the unavailability of such parts.

14. Attention be given to facilitating to the greatest extent possible the importation and nationalization of equipment, supplies, and spare parts necessary for research and teaching, especially when the institutions have the necessary foreign currency available.

## II. AGRICULTURE AND NATURAL RESOURCES

1. In the interest of expanding critical programs, such as geologic mapping, mineral exploration and hydrologic studies, as rapidly as possible, it is of greatest importance that Colombia increase the number of highly qualified geologists, geophysicists and other earth scientists at least tenfold by the end of the century.

It is essential that persons in the earth sciences be well-trained, capable of conducting research and field surveys on a level comparable to that undertaken in the technologically more advanced countries. Applied research programs must be backed up by basic research in the earth sciences.

In order to speed up education, training, research, and surveying programs, it is urged that long-term institutional links be established between departments of earth sciences in Colombia and appropriate departments of high quality in other countries. Special effort should be made to interest scientists in foreign universities in the geological and geophysical problems of Colombia and to attract graduate students to do their theses in these fields.

2. In areas where studies of mineral deposits, and cartographic and explorative work are being conducted, it is urged that the effort be undertaken within the framework of technological and economic analysis so that priorities of commercial development can be determined at the earliest possible stage. The responsibility for this activity should be placed in a carefully-selected research organization, perhaps one created for this purpose.

3. It is recommended that:

a. Special emphasis be placed on the development of an

effective agricultural and animal husbandry extension program.

- b. Massive middle-level personnel training programs be established immediately in agricultural technology, using highly-qualified and specialized professional instructors, for the purpose of bringing technology to the rural areas.
- c. Studies be conducted to determine effective means for resolving the problem of communication between those who develop technology and the farmer or cattle rancher who applies it.

4. Special emphasis should be given to research in the following areas:

- a. Tropical areas and products
- b. Beef cattle
- c. Vegetable fats and oils
- d. Basic food products in accordance with the government plans, consideration being given to the need for improving the quality, especially of the proteins
- e. Crop production methods
- f. Social and economic studies, including farm management, the economics of production, marketing, and community studies.

5. Training and competence should be given recognition by providing adequate salaries, promotions, and opportunities for professional recognition and advancement.

6. In view of the tendency of individuals and institutions to confine their studies to their own disciplines, it is recommended that ad hoc working groups be formed to determine, discuss, explain, and recommend fields in which problems have already been identified.

7. Recognizing the great value of and the need for developing experimental laboratory work in the education and training of scientists and engineers, it is recommended that a reasonable amount of field work be included in the curricula in all areas where this is considered feasible.

8. It is recommended that in policies for research and development, priority be given to problems connected with the industrialization of agricultural products, and that adequate financial resources be allocated for these requirements.

9. It is suggested that advances in science and technology be properly reflected in legislation concerning mining and petroleum, for the purpose of protecting the interests of the country.

10. It is recommended that encouragement be given to the following initiatives already undertaken by academies and higher education centers:

- a. Coordination of university plans with those of other institutions interested in the study and conservation of natural resources;
- b. Organization and dissemination of the Colombian bibliography on these resources; and
- c. Establishment of special programs on the primary and secondary school levels and within the community environment, aimed at the creation of an attitude of protection and proper utilization of the country's natural environment.

11. Because Colombia is to a great extent economically dependent on the production and exportation of coffee, it is very important to diversify exports and develop crops that can substitute coffee. The achievement of these objectives must be an important consideration in the research and development programs presented in these recommendations.

### III. INDUSTRY

1. The Workshop emphasized the valuable accomplishment of the Institute of Technological Research (IIT), in research and development which have contributed much to the nation's industry during the last ten years. The Institute should be expanded and given the resources it requires to participate more widely and intensively in industrial activities and related technological problems. For this purpose, the Institute must be open to the sponsorship and participation of private industry and the government. The latter sectors should utilize the Institute's services on a larger scale, thus strengthening its financial resources.

It will be necessary to expand the board of directors and management of the Institute in order to accomplish the following goals: a) include recognized authorities from the most important industrial sectors; b) coordinate its activities with financial, industrial, and university institutions; c) expand its radius of action throughout the country; d) specialize its tasks on the regional level to correspond with the most important industrial sectors and to establish bonds with technological research institutes in other countries, through bilateral cooperation and exchange agreements on specific research projects. Some of the specific work which could be done by the Institute would be to transform and adapt international technology for use in Colombia, and to develop, evaluate, and apply processes of industrial production suited to the needs and resources of Colombia. It is also recommended that the Institute expand its

existing library so that it will be capable of providing documentation service on industrial technology on a nationwide scale.

To accomplish these tasks, the Institute must be allocated the required economic resources.

2. It is recommended that the Colombian Institute for Advanced Training Abroad (ICETEX) create and maintain a permanent register of Colombian students abroad by means of the following:

- a. Periodic questionnaires for the purpose of gathering information from all students;
- b. An active drive to inform public and private research organizations in Colombia about prospective engineers, scientists, and executives who are finishing their studies abroad, etc;
- c. Public recognition of the efforts of employers who hire students and of students who return to Colombia; and
- d. Just prior to graduation, a recruiting commission should be sent to principal U.S. universities which have Colombian students in order to establish contact between potential employers and Colombian students.

It is also recommended that ICETEX attempt to interest selected industrial research organizations and laboratories in the United States, Europe, and Latin America. in accepting properly-qualified Colombian graduates to work for one or two years in their laboratories as part of their research programs. and that ICETEX familiarize Colombian employers with such individuals through the registration system described above. The purpose is to help place these students satisfactorily within Colombian research and development activities, upon completion of their training abroad.

3. It is recommended that necessary measures be taken to launch a study of the legal aspects of patents and trademarks in Colombia, to determine revisions which may be necessary to protect research conducted in Colombia, and to facilitate the optimum development of Colombian industry in accordance with conditions prevailing in the country.

4. Visits of industrial groups to countries with advanced technologies should be promoted and facilitated, for the purpose of examining the possibility and feasibility of adopting new technologies in Colombia.

5. It is recommended that technological research institutions maintain permanent contact with industry, through conferences with

industrial associations.

6. Contacts between industrial leaders and university and researchers should be encouraged, in order to facilitate teaching by industrial scientists at the universities, to train university professors and students in industrial problems, and to work out joint research projects which will improve and modernize industrial processes.

7. It is recommended that the Institute of Technological Research or the Institute of Industrial Development (IFI) create a permanent service for the identification and study of patents recently granted in other countries, to determine their possible utilization in Colombia, and to disseminate information about those patents to industries interested in applying these ideas.

8. Government support of science and technology should take into account the priorities established by the National Planning Department. As obstacles and limiting factors are identified in the various economic sectors, measures must be taken to resolve problems through technological processes. The appropriate technology should be developed within the country, whenever possible, without excessive additional expenditures. It is not advisable to allocate funds for research and development to industries in which the achievement of a reasonable degree of efficiency, by international standards, is improbable, except in the face of important considerations, such as creation of new jobs or saving foreign currency.

#### IV. POLICY FOR SCIENCE AND TECHNOLOGY

##### Points on a policy for the development of science and technology in Colombia and tentative outline of corresponding executive and financial structures

The Workshop on Science and Technology for Development takes the liberty of recommending to competent authorities a study for the creation of necessary administrative structures and the adaptation of the existing ones for the purpose of formulating and carrying out a policy which would vigorously promote science and technology in Colombia in accordance with the country's needs and its objectives and goals for development at the national, sectoral, and regional levels.

The workshop specifically suggests the establishment of a top-level executive agency, in accordance with government administrative organization, having legal status, its own capital, and permanent administrative and financial flexibility. This will facilitate

its adaptation to the responsibilities which it must assume in order to carry out its functions successfully and in harmony with standards which will assure employment of properly qualified personnel.

This organization should serve as an administrative and executive instrument of a national council for science and technology, which would be composed of outstanding persons from these disciplines and from those sectors which utilize these disciplines. This agency would advise the national government in the formulation of a realistic policy for science and technology, would evaluate official programs that are undertaken, and make permanent recommendations for measures important to insuring rapid and dynamic progress in such important matters.

It is also believed that this council and its corresponding executive agency should have sufficient budget resources so that they can properly carry out their programs. Therefore, it is considered advisable to create a special fund which will enable the agency to provide financial support for the implementation of qualified projects in the fields of science and technology.

The workshop believes that the council, its executive agency, and the fund should have, among other things, the following objectives:

- a. To insure that the development of government-subsidized science and technology is handled in accordance with the goals and objectives of overall development plans;
- b. To advise on the creation or improvement of administrative mechanisms which would enable each government sector to undertake, sponsor, or promote research related to its own objectives;
- c. To advise on the creation of mechanisms in the public and private sectors designed to carry on industrial research of importance to the national economy;
- d. To prepare, in accordance with the Administrative Department of Planning and governmental and private agencies, a plan for scientific and technological development which will be realistic and which can be properly carried out;
- e. To coordinate research programs within the governmental sector as well as within the private sector;
- f. To advise on the adequate use of public funds in various research programs, and to orient the allocation of these funds toward support of basic and applied

research carried out in the scientific departments of the universities;

- g. To promote, in agreement with the Ministry of National Education (National University Fund), post-graduate education in the basic sciences, in the various fields of engineering, and in the technologies most directly related to national development;
- h. To advise the Ministry of National Education on the preparation and development of plans, study programs, and education curricula in the sciences, particularly in mathematics, at the primary and secondary levels of education;
- i. To establish relationships with academies and private professional associations for the purpose of obtaining the benefit of their collaboration, recommendations, and criticism;
- j. To organize every two years a national congress on science and technology, for both public and private sectors, for the purpose of exchanging information on plans and projects, evaluating advances achieved, identifying obstacles, and searching for solutions;
- k. To organize seminars, work groups, and other similar meetings, with participation by foreign personalities whenever this is feasible;
- l. To promote the participation of Colombian delegates in international scientific and technological meetings, both public or private, to allow appropriate review of the respective agendas and also the dissemination of reports; similarly, to promote meetings of this type in Colombia;
- m. To advise the Colombian government on its relations with international organizations in fields of science and technology;
- n. To study the problems and solutions related to the policy for Latin American integration in the field of science and technology and submit pertinent recommendations to the government;
- o. To assure that the educational system provide, in adequate quantity and quality, the expert professional and technical personnel necessary at all levels for the development of

science and technology and, in addition, recommend measures for optimum utilization of existing trained personnel;

- p. To recommend effective measures to facilitate the return of Colombian scientists and engineers who are abroad;
- q. To ensure that scientific and technological development is decentralized so as to benefit all regions of Colombia;
- r. To facilitate, through various government agencies, means that will assure extension of research results so that all sectors of the economy will achieve more effective production, for which extension support should be sought from the private sector;
- s. To promote, in association with or through the respective governmental department, the development of the statistics required for its activities;
- t. To study and promote everything related to scientific documentation and its appropriate organization and dissemination;
- u. To prepare and maintain an up-to-date inventory of all Colombian science and technology assets;
- v. To maintain permanent and close relations with similar organizations in other countries for the purpose of utilizing their experience and assistance;
- w. To guarantee, on a permanent basis, high quality research activities, and in fulfilling this responsibility, to promote the selection of personnel solely on the basis of their duly-accredited merit and experience.

In connection with the financing of research, the workshop submits the following recommendations to the appropriate authorities for study:

1. In addition to current investments, an official Scientific Research Fund should be created to which the government would initially contribute no less than 0.2 percent of the Gross National Product of the preceding year.

An attempt should be made to have public and private funds, as well as external assistance, increased to one percent of the Gross National Product during the first ten years. One of the objectives of the work group proposed below should be to determine the current level of investments in this field, and to study means of channeling the

resources necessary for accelerating the development of research.

One of the principal purposes of this Fund would be to finance agricultural research of the Colombian Agriculture and Livestock Institute (ICA), to include and integrate other programs, such as the cotton, tobacco, coffee, rice, and banana programs, with the eventual cooperation of the International Center for Tropical Agriculture.

Similarly, this Fund should provide adequate financing for the Institute of Technological Research, the Institute of Nuclear Affairs, the Caro and Cuervo Institute, and other legally constituted institutions, in accordance with official development plans and with the cooperation of universities.

The Fund should also provide the means to contract with universities and well-established institutes for graduate and undergraduate studies in the human, social, administrative, mathematical, physical, chemical, and natural sciences, as well as engineering, in order to support scientific and technological research, in accordance with plans outlined in the respective contract. Through these contracts the Fund would finance research projects which would guarantee full-time work, and adequate salaries for professionals with advanced degrees. This would of course be based on previous evaluation of the importance of the project in terms of national development and the assurance that it will be carried out at an internationally acceptable scientific level.

2. The issuance of a legal disposition which will authorize corporations or individuals with profits of more than 12 percent per year to deduct from their net income sums equal to double the amount of the financial contributions given to any government-recognized universities carrying out research programs approved by Fund authorities.

3. The workshop suggests that the Colombian Government establish a work group to study the above conclusions and prepare the legal and financial formulas required for the organizations described above and, in general, to offer advice regarding the steps necessary for the accomplishment of the proposals recommended at this meeting.

4. The specific recommendations and conclusions presented to the plenary session by each of the commissions (education, agriculture, and natural resources and industry), which are appended to this document, shall be communicated to the national government, the academies, the universities, and the research institutes for their study, comments, and, if feasible, application.

## CONTRIBUTED PAPERS

Session I

Harrison Brown, Science Policy and Economic Development

Session II

Gabriel Betancur and Oliverio Phillips, Comments on the Need for an Overall Scientific and Technological Policy in Colombia

Universidad del Valle, What is the State of Educational Research in Colombia?

Session III

Enrique Blair and Alberto Franco, Problems of a Technical Nature which Influence the Development of the Agricultural and Livestock Sector

Colombian Agricultural Institute, Analysis of the Technical Problems that Colombia Faces in the Development of its Crops and Livestock Sector

Darío Suescún, Non-Renewable Natural Resources

Zven Zethelius, Analysis of the Problems the Country Faces in the Development of Research

Ramiro Tobón, Analysis of the Problems which Confront Colombian Universities in the Development of Research

Session IV

Gabriel Poveda, Technical and Scientific Investigation for Industry in Colombia

Karl Folkers, Solution of the Problems of Industry and Government through a Research Institute

The following has been translated from an article by Gabriel Cantor Zabala which appeared in the Bogotá newspaper, La República, March 2, 1968.

#### THE COUNTRY HARDLY KNOWS ITSELF

"The country continues to be incognito, knowing little about itself," stated President Lleras Restrepo at the San Carlos Palace during the closing session of the first Workshop on Science and Technology for Development.

The Chief of State spoke to the workshop participants and approximately fifty special guests, following remarks by Drs. Ospina, Betancur Mejía, and Harrison Brown, who made specific reference to the conclusions adopted during the workshop held in Fusagasugá this past week.

The President expressed satisfaction with the recommendations presented and announced that the proposed study groups will be established as soon as possible.

He acknowledged the Government's views that all support necessary be given to research as a special resource for development, and expressed complete agreement with the workshop conclusions, which include the following vital points:

1. Knowledge of our resources.
2. Establishment of groups and centers for research.
3. Centers for disseminating the results.

He cited several institutions in the country which are carrying out advanced research, especially in the utilization of national resources, but pointed out that the most intense activity should take place in the universities.

#### Complete Knowledge

Continuing his remarks, which were interpreted simultaneously into English, Dr. Lleras stated that all research should be oriented toward the national welfare, and toward this end, it is necessary to know the Colombian citizen and the structure of his country.

Analysis of the resources and conditions of the community groups will make progress in this work possible, he added.

The broad scope of the recommendations will permit the application of science to improving living standards.

### Halt to the Brain Drain

The President said the Government understands the need to progress in these areas, through active, operating institutions as a means of retaining scientists currently being trained and who are seeking places to put their knowledge into practice. However, in addition to organizations of this type, it is also necessary to disseminate the results of practical research in order to reach the people.

Channels must be created to carry the synthesis of this research to the different sectors of the economy. This implies administrative capability for effective application of research findings to daily life.

Upon expressing his appreciation for the collaboration lent by the United States delegation, he emphasized that a new era will begin in the country which marks, at the same time, a new type of international cooperation.

In conclusion, he expressed regret that he had been unable to attend the workshop and thus make direct contact with persons of such scientific knowledge and experience as the invited guests.