Pan American Health Organization World Health Organization

XXVIII MEETING OF THE ADVISORY COMMITTEE ON HEALTH RESEARCH

Montevideo, Uruguay
20-23 August 1991

ACHR 28/91.5
Original: Spanish

SCIENCE AND TECHNOLOGY IN THE DEVELOPMENT OF LATIN AMERICA

Dr. Enrique Martín-del-Campo
Director, ROSTLAC/UNESCO
Montevideo, Uruguay
July 1991

I. THE SIXTIES AND SEVENTIES

Two and a half decades ago there was an urgent need to create and develop the scientific and technological infrastructure of Latin America. Scant government resources were allocated to these endeavours, and the programmes of international organizations like the OAS and UNESCO represented a small yet significant contribution to the government budgets of the region's countries.

Scientific communities, when they did exist, were concentrated almost exclusively within university campuses. The concern for linkages with the productive sector was coming to be seen merely as a need for industry to approach scientists, on the latters' terms, in order for relationships to be created. During those years the OAS and UNESCO were actively involved in promoting the organization of scientific sectors through the establishment of national scientific and technological organizations (NSTOs), which started appearing for very varied internal reasons, from the almost "pure" thrust of the scientific sector in Venezuela, to the highly politicized interest arising out of the "1968 events" in Mexico.

In the '70s, years of peacefulness and relative prosperity for the region, the concept of linkages with the productive sector arose as a substantial change in the basic '60s idea of creating a supply of research that would automatically be used by the countries' production apparatus.

Clear efforts were also made to link science and technology policies to national development policies. Increasing emphasis was placed in particular on the importance of the company as the place where the central process of technological change takes place, and the fact that such change would act as the main axis of national science and technology policies.

In general, the factors of national and international investment were clearly identified as major channels for introducing technology in production, with importance being given to vertical integration of production and thus to development of the capital goods sector as an instrument for the growth of an endogenous technological capacity.

Likewise underscored was the need for and importance of technological training and of gradual, step-by-step technological change, where linkages are formed among the diverse production agents, as well as R & D, including the major role of basic sciences.

This period also brought environmental factors to light, along with the need to maintain ecological balance and to adapt technologies to suit that balance, as well as the country's resources.

At the institutional level there arose a clear trend of NSTOs as relatively marginated institutions, incapable of penetrating the production sector, especially in the case of private enterprise. They were also unable to exert an influence on public spending, to reach the mystical goal of 1% of GNP. (1)

Part of that marginality derives from the basis out of which a large part of science and technology policies grew: the almost magical concept of the linear and virtually automatic effects of scientific research on technological production, as the pioneers of science policy in many of our countries saw it.

This gave rise to a limited capacity for understanding the mechanisms required for intersectorial linkage. Many specialists indicated that if this could take place in the U.S., at institutes like MIT, at Bell Laboratories, and on Route 28 outside of Boston, it was necessary to find similes in our countries that would produce the same effect. What they did not realize, however, was that those interactions took place chiefly due to the thrust of strategic projects primarily linked to the needs of the industrial-military complex and to reasons more akin to state security than to the demand for products by the civilian sector of the U.S. population. (2) It was only in the '80s that the mechanisms for linkages with the civilian sector began to be clearly seen.

II. THE DECADE OF DE-DEVELOPMENT

While it can be said that by the beginning of the '80s there had been relative achievements in many countries, some of them impressive in terms of their effect on the development of certain sectors of great economic and strategic importance, the general reality is that the advances were basically due to various aspects of science and, particularly, technology policies. (3)

Statistics available for those years show that Argentina and Chile took better advantage of their investments in science and technology than Mexico, Venezuela and Costa Rica. As regards the number of scientists and engineers in R & D, Brazil almost doubled (32,000) the number in Argentina and mexico (18,900 and 18,200, respectively), who were immediately followed by Cuba with 13,800. The Andean countries, with the exception of Ecuador, had an average of 4,500 each, and the rest of the region's countries averaged no more than 1,000 each. (4)

The effort begun in the '60s of training the human resources required to form true scientific-technological bases can be seen in these numbers, since 10 or 12 years earlier practically none of the larger countries exceeded 4,000 scientists and engineers, while in Mexico the figure was even less than half that.(5) Unfortunately, only six of the larger countries have made the massive, long-term

effort and the million-dollar investments required for the training of high-level resources.

In the past decade the international economy has undergone structural changes deriving, inter alia, from waves of technological innovation. The most dynamic sectors of the economy are no longer the traditional ones (steel, cement, basic chemistry), but instead the high-tech, know-how intensive ones. The current processes of industrial restructuring and changes in technological models revolve around the information industries.

Production based on scale economies (large volumes, standardized products, large markets) are giving way to flexible production (diversified products). In addition to the scale economies we see the appearance of a product range economy. Flexible technologies permit production in small quantities for small markets, with a variety of products. Idle capacity and equipment obsolescence are reduced; input specifications become more flexible (quality, diversity). There is a drop in working capital (stock of raw materials, products in process, finished products), production is restructured and reorganized. As a result, payments to unskilled labour become less important in the structure of production costs.(6)

The economic crisis in which the region is still emersed has also heavily impacted on investments in science and technology and on the education sector in the vast majority of the countries, creating two dramatic effects. The first is the drastic reduction of all resources allocated to R & D, although resources for basic research and higher education were reduced in even greater proportion than resources for applied research and technology. The second is the immigration of a great number of scientific researchers and engineers to industrially developed countries, particularly the U.S.

The combination of these two effects can be highly dangerous, possibly even more so than capital flight, since the longer the crisis lasts, the more likely it is that those researchers and engineers, and their families, will not return, given that they will have developed deep roots in their new places of residence, and the investment made in them by the developing countries will have been permanently lost. In contrast, financial resources can be repatriated, along with the interest earned, as soon as conditions are ripe.

In the middle of the decade the Academy of Sciences of Latin America had the following to say regarding the region's scientific sector:

"The number of Latin American and Caribbean scientists of recognized international quality is low, and there is a clear lack of specialists in certain areas that are critical for the region.

Recent statistics indicate, for example, that although Latin America has 10% of the planet's population, it contributes less than 1% to world production of science, and that 92% of regional production comes from only five of the region's countries.

"The economic resources allocated by governments to scientific research and technology in the five Latin American countries that produce 92% of the region's science, are five to ten times less in terms relative to national product, which in itself is lower than in the developed countries. For the rest of the countries in the region the amount is less still, or nonexistent.

"Added to the scant resources allocated by the governments to science, in many cases there is also the fact that the allocation of funds to research projects is made without the participation of scientists, and disregarding the fact that the projects must be managed and led by recognized, high- level scientists. This leads to the failure of many projects and the appearance of a class of persons who, while they may have a university degree, are "pseudo-scientists" in the strict sense, since they are lacking in the qualifications of scientists and yet try to exercise the functions of scientists.

"Economic instability, accompanied in many countries by political instability, hinders the growth of the scientific community in Latin America and the Caribbean, leading to the migration of many scientists to developed countries, and making scientific activity unappealing to new generations.

"In many countries, rigidity and the excessively 'professionalizing' structure of higher education systems fail to promote scientific vocations and encumber interaction among the different scientific disciplines.

"Integration and the exchange of scientists among the different Latin American countries is far from reaching an adequate level." (7)

At the end of the '80s, we faced the real and cruel fact of a period of extreme financial limitations and a gradual abandonment of government investments in social and economic sectors. This continues to profoundly affect science and technology, along with higher education. In this decade only Brazil and later Chile managed to increase their investments beyond 1980 levels. (8)

At the same time, we saw the birth of a new wave of technology, a challenge to get beyond the limitations on exports which gave rise to a clear need to create local technology and industrial designs that would be competitive in real terms on the international market.

This new awareness has also awakened the need to reassess the role, somewhat forgotten in the '70s, of science and basic scientific research, not in the linear and Cartesian format mentioned above, but instead as an essential element in the creative whole required of any model assumed for international insertion of the countries of Latin American in the post-Brady Plan future.

Universities have had to be perceived as a resource usable by and for the processes of economic-social development. The universities, in turn, have tried to respond to the challenge not only for financial reasons, but also reasons of a political sort and of image. Thus the borders of basic and applied research begin to disappear, creating intermediary areas where the requirements are of a strategic ilk. This is most visible in the sphere of so-called high technologies, which have "a very basic dynamics," and potential short-term applicability. (9)

III. WHERE ARE OUR SCIENCE, TECHNOLOGY, AND DEVELOPMENT GOING?

F. Sagasti commented that:

"The growing interrelationship between factors of a scientific and technological nature, on the one hand, and those of an economic, financial, social, political, environmental and culture nature, on the other, demand a comprehensive treatment of development policies... It is necessary to give greater visibility to the scientific and technological aspects of the development process; moreover, the efforts to establish and consolidate own scientific and technological capacity in the countries of the region must be seen as a 'national crusade'." (10)

The conflict between the university "ethos" and the business sector is no longer so much so, and we see the reconciliation of interests, perhaps forcibly brought on by the structural, economic change that has come over us. (11) Thus, in this decade, we see the appearance of the "gatekeeper," the "entrepreneur," the leader in the process of linkage between the basic research taking place at universities and the growing demands of the private sector.

The new conditions defined by the overwhelming appearance of microelectronics, informatics and rapid telecommunications, and their influence on the entire development process of the countries, either due to their presence or their absence, obviously also require a new vision of the context in which an advanced technological capacity can be developed in our countries with a real scientific basis. The use of satellite systems to break the incommunication barrier of our scientific communities, along with rapid access to technological information and discussions in other parts of the world, are now possible using instruments based on microelectronics and which are merely an example of what can exist in terms of a new way of organizing what has come to be known as

"networking," the system of interpersonal relations among research, and between researchers and the other actors in the process of linkage at national and international levels.

The transition toward a paradigm of technological information (12) clearly defines new and innovative visions of non-traditional routes for developing countries willing and able to take advantage of the right moment.

Certainly the push into new routes can be more effective if at the same time there can be development of processes of integration among countries of the region such as those so interestingly outlined by the members of the Rio Agreement (G-8). (13)

But in all these future processes we will have to take into account that "science and technology must cease to be an exogenous variable in the processes of economic and social reconstruction"... and that the "search for peace and democracy must necessarily involve... reassessment and promotion of science and technology... as practices committed to the social basis of our countries." (14)

Does the challenge of the '90s imply going back to a "new international crusade"? The answer is definitely not. "Either we invent or we fail" are words as current today as they were when Simón Bolívar heard them from his teacher Simón Rodríguez.

The challenge, domestically, is to deal with the subject of Science and Technology as part of the national strategy, part of the country's project for "economic security," and to act internationally in keeping with that concept. The countries that develop and use their technological capacity as part of their international political strategy will certainly be the ones to see positive results at the outset of the 21st century.

The challenge is for each country to also make use of the paradigms proposed by informatics and biotechnology, but also to find among the ruins of the debt, the will and the need to cooperate with neighboring or sister countries to create partial or total integrations that reinforce their capacity to reach a stage of self-sustained development upon the dawn of a new century, by means of a science effectively linked to development, and a technology truly based on science and at the service of the development of our peoples.

The scientific sector specifically demands concrete steps by governments, such as:

- Supporting public and private organizations promoting or performing scientific and technological research. Government support is especially important now, when the economic difficulties affecting all the countries of the region have led

to an undesirable decrease in the real value of the resources allocated to science and technology.

- Establishing degree programmes for Scientific Researchers in those countries of Latin America and the Caribbean where they still do not exist. Such programmes provide a mechanism for identification and selection of the most competent scientists in each country and favours the stability and appropriate remuneration of same.

- Including researchers having recognized competence in the management of agencies responsible for designing and executing programmes related to science and technology.

- Facilitating the importation, duty- and surtax-free, of equipment, materials and publications for scientific and technological research.

- Promoting funding for grants and devoting existing resources to financing master's and doctoral studies for deserving students and to scientists for forming productive research groups. The amount of grants should permit full-time, exclusive involvement in studies. Post-graduate programmes to be financed should be chosen using the same criterion of excellence. This will avoid dispersion of economic resources and will preserve the good level of training of scientists. (15)

- Investing new resources in Higher Scientific Education and fostering innovative technological production are the only possible routes for future development of the countries of the region.

The study, planning, financing, programming and evaluation of science and technology activities in Latin America face several challenges (6):

1. The need to concentrate efforts. General, horizontal advances in the diverse scientific and technological fields cannot be sought; instead, areas should be chosen for concentration and excellence.

2. Insertion and integration of the science and technology variable in the political processes of defining strategies and decision-making.

3. Scientific and technological activity planning, coordination and promotion agencies should be located outside the spheres of influence of the ministries of education and be directly linked to the ministries of the presidency, finance or planning.

4. The training of intellectual capital, of scientific and technical personnel at post-graduate level.

5. Technological research should stand on two legs:

   a. valuation and upgrading of endogenous technologies; and
   b. adaptation and assimilation of new technologies and of frontier technologies.

6. The strengthening of the process of management and transfer of technology at micro level, of linkage of research to production units. There should be a decrease in emphasis on formal, legal and institutional modes for marketing technology (which is not transfer), as expressed in laws on technology transfer, registration of technology licensing agreements, legal regulation of restrictive clauses in contracts for technology licensing, industrial property, etc. Consequently, there should be a strengthening of technology management and transfer mechanisms geared to small and mid-scale industrial and agricultural enterprises.

7. Improvement of the measuring of scientific and technological activities, the definition and use of endogenous science and technology indicators, and the preparation of detailed diagnoses relevant to decision-making.

8. Strengthening of scientific and technological information services.

9. Strengthening of national consultancy and technical assistance services.

10. Formulation and execution of comprehensive projects for investment in science and technology.

11. Integrated participation of the industrial private sector in the definition of the needs for technological innovation and for investment in S & T.

For multilateral international organizations, the challenge is whether or not to continue setting the pace for the countries. It is necessary to catalyze the initiatives of the member countries, but not to impose ideal multi-agency projects framed by priorities defined by their at times out-moded sectorial structures.

Perhaps the best action programme for the 1990s is to address the priorities of each of the developing countries, and at the same time to support and reinforce the movements and initiatives for cooperation and integration undertaken by them in their different forms, vehicles and time frames.

On its part, the Unesco Regional Office for Science and Technology for Latin America and the Caribbean (ROSTLAC) has raised

several considerations in this regard, which I will point out as a general conclusion to this paper (16):

1. It is fundamental to promote the development of rural zones, disadvantaged populations groups, and to contribute to promotion of the development of women;

2. From the standpoint of science and technology, own strategies must be established, based on the demands generated by the global strategy. Isolated national efforts are not sufficient for triggering the process of sustained development and surmounting the crisis in the short or the long term. Consequently, the global strategy must have a regional dimension. In turn, the science and technology strategy must be geared to the creation of a joint capacity making it possible to reach the proposed objectives and goals in a reasonable time period;

3. A regional science and technology system should also be structured to act as a valid interlocutor with the scientific and technological systems of the more advanced countries. The structuring of such a system implies a sustained long-term effort;

4. The development of scientific and technological capacity also implies the need to initiate immediate actions for surmounting the deficiencies of current scientific and technological efforts, which tend to be:

   a. limited, with a slow growth rate and a short-term vision;

   b. distributed heterogeneously over the countries and within specific sectors;

   c. insufficiently articulated internally between institutions and economic agents;

   d. low level in terms of effectiveness;

   e. insufficiently articulated regionally;

5. The immediate actions that will make it possible to surmount these deficiencies should be geared, among other things, to:

   a. development of the basic sciences;

   b. strengthening of abilities to transfer and assimilate technologies in keeping with the strategies established and the characteristics of the region;

   c. development of assimilation capacities;

d. training very highly skilled scientific and technical personnel;

e. strengthening of the capacities for prospecting, planning, management and assessment of science and technology;

f. strengthening of the national science and technology structures, enabling all countries of the region to fully and fairly participate in the application of regional strategies and the use of their results;

g. strengthening of the capacities for design and application of mechanisms and instruments of science and technology policy;

h. creation and strengthening of financial mechanisms for technological innovation;

i. development of linkages between economic- educational-research agents;

6. The creation of joint capabilities in science and technologies implies moving from the stage of cooperation into that of integration, and thus requires an in-depth analysis of the ways in which this should take place;

7. In compliance with the mandates from the highest political levels in the region, international, regional and bilateral cooperation agencies should intensify their actions so as to aid in achieving the goals of creation of joint scientific and technological capabilities and regional integration.

REFERENCES AND BIBLIOGRAPHY

(1) PRDCYT-OAS.1 "Desafíos de las Políticas Científicas y Tecnológicas y de Institucionalización en América Latina y el Caribe." Internal OAS communication. April 1989.

(2) Enrique Martín del Campo, "La Política Científica y Tecnológica en los Estados Unidos de América." CIENCIA Y DESARROLLO, No. 19. March-April 1978.

(3) PRYDCYT-OAS.1 - ibid.

(4) Francisco R. Sagasti. "Perspectivas futuras de la Ciencia y la Tecnología en América Latina" in "LA TERCERA REVOLUCION INDUSTRIAL-Impactos Internacionales del Actual Viraje Tecnológico" Carlos Ominani, Editor. RIAL, Grupo Editor Latinoamericano 1986.

(5) María Luis Salas de Gómez Gil. "Inventario de la Ciencia y la Tecnología en México." Documentos del INIC. Mexico 1969.

(6) Eduardo Martínez. (1988), La integración de la ciencia y la tecnología en la planificación del desarrollo en Uruguay - Introducción. (UNESCO/OPP, Montevideo, pgs.1-11).

(7) Academia de Ciencias de América Latina - "La Ciencia en América Latina: Situación actual y recomendaciones." Document by the Board of the Academy. April 1984.

(8) PRDCYT-OAS.2. Datos Estadísticos de Ciencia y Tecnología en América Latina. Internal document. August 1989.

(9) Mario Waissbluth. Private communication. July 1989.

(10) Francisco R. Sagasti. "Crisis y Desafío: Ciencia y Tecnología en el futuro de América Latina." Publicaciones de GRADE, Lima, Peru.

(11) Mario Waissbluth, ibid.

(12) C. Freeman and C. Pérez. "Structural crisis adjustment: business cycles and investment behaviour" in G. Dossi, C. Freeman, R. Nelson, G. Silverbert and L. Soete (Eds.), Technical Change and Economic Theory, London, Pinter Publishers, 1988.

(13) UNCSTD. "Development of Science and Technology in Latin America and the Caribbean." Regional review paper, Centre for Science and Technology for Development. United Nations. February 1989.

(14) Manuel Angel Castillo. "Ciencia, Tecnología y Cambio Social." CITGUA A.C. Memorias del III Congreso Latinoamericano sobre

políticas científicas y tecnológicas. San José, Costa Rica. 1-4 March 1988.

(15) Academia de Ciencias de América Latina. ibid.

(16) UNESCO/ROSTLAC. (1988), Reunión sobre la evaluación de conferencias regionales y la cooperación futura de Unesco en ciencia y tecnología - Informe Final (Unesco, Montevideo).

Pan American Health Organization World Health Organization

XXVIII MEETING OF THE ADVISORY COMMITTEE ON HEALTH RESEARCH

Montevideo, Uruguay
20-23 August 1991

ACHR 28/91.5
Original: Spanish

SCIENCE AND TECHNOLOGY IN THE DEVELOPMENT OF LATIN AMERICA

Dr. Enrique Martín-del-Campo
Director, ROSTLAC/UNESCO
Montevideo, Uruguay
July 1991

I. THE SIXTIES AND SEVENTIES

Two and a half decades ago there was an urgent need to create and develop the scientific and technological infrastructure of Latin America. Scant government resources were allocated to these endeavours, and the programmes of international organizations like the OAS and UNESCO represented a small yet significant contribution to the government budgets of the region's countries.

Scientific communities, when they did exist, were concentrated almost exclusively within university campuses. The concern for linkages with the productive sector was coming to be seen merely as a need for industry to approach scientists, on the latters' terms, in order for relationships to be created. During those years the OAS and UNESCO were actively involved in promoting the organization of scientific sectors through the establishment of national scientific and technological organizations (NSTOs), which started appearing for very varied internal reasons, from the almost "pure" thrust of the scientific sector in Venezuela, to the highly politicized interest arising out of the "1968 events" in Mexico.

In the '70s, years of peacefulness and relative prosperity for the region, the concept of linkages with the productive sector arose as a substantial change in the basic '60s idea of creating a supply of research that would automatically be used by the countries' production apparatus.

Clear efforts were also made to link science and technology policies to national development policies. Increasing emphasis was placed in particular on the importance of the company as the place where the central process of technological change takes place, and the fact that such change would act as the main axis of national science and technology policies.

In general, the factors of national and international investment were clearly identified as major channels for introducing technology in production, with importance being given to vertical integration of production and thus to development of the capital goods sector as an instrument for the growth of an endogenous technological capacity.

Likewise underscored was the need for and importance of technological training and of gradual, step-by-step technological change, where linkages are formed among the diverse production agents, as well as R & D, including the major role of basic sciences.

This period also brought environmental factors to light, along with the need to maintain ecological balance and to adapt technologies to suit that balance, as well as the country's resources.

At the institutional level there arose a clear trend of NSTOs as relatively marginated institutions, incapable of penetrating the production sector, especially in the case of private enterprise. They were also unable to exert an influence on public spending, to reach the mystical goal of 1% of GNP. (1)

Part of that marginality derives from the basis out of which a large part of science and technology policies grew: the almost magical concept of the linear and virtually automatic effects of scientific research on technological production, as the pioneers of science policy in many of our countries saw it.

This gave rise to a limited capacity for understanding the mechanisms required for intersectorial linkage. Many specialists indicated that if this could take place in the U.S., at institutes like MIT, at Bell Laboratories, and on Route 28 outside of Boston, it was necessary to find similes in our countries that would produce the same effect. What they did not realize, however, was that those interactions took place chiefly due to the thrust of strategic projects primarily linked to the needs of the industrial-military complex and to reasons more akin to state security than to the demand for products by the civilian sector of the U.S. population. (2) It was only in the '80s that the mechanisms for linkages with the civilian sector began to be clearly seen.

II. THE DECADE OF DE-DEVELOPMENT

While it can be said that by the beginning of the '80s there had been relative achievements in many countries, some of them impressive in terms of their effect on the development of certain sectors of great economic and strategic importance, the general reality is that the advances were basically due to various aspects of science and, particularly, technology policies. (3)

Statistics available for those years show that Argentina and Chile took better advantage of their investments in science and technology than Mexico, Venezuela and Costa Rica. As regards the number of scientists and engineers in R & D, Brazil almost doubled (32,000) the number in Argentina and mexico (18,900 and 18,200, respectively), who were immediately followed by Cuba with 13,800. The Andean countries, with the exception of Ecuador, had an average of 4,500 each, and the rest of the region's countries averaged no more than 1,000 each. (4)

The effort begun in the '60s of training the human resources required to form true scientific-technological bases can be seen in these numbers, since 10 or 12 years earlier practically none of the larger countries exceeded 4,000 scientists and engineers, while in Mexico the figure was even less than half that.(5) Unfortunately, only six of the larger countries have made the massive, long-term

effort and the million-dollar investments required for the training of high-level resources.

In the past decade the international economy has undergone structural changes deriving, inter alia, from waves of technological innovation. The most dynamic sectors of the economy are no longer the traditional ones (steel, cement, basic chemistry), but instead the high-tech, know-how intensive ones. The current processes of industrial restructuring and changes in technological models revolve around the information industries.

Production based on scale economies (large volumes, standardized products, large markets) are giving way to flexible production (diversified products). In addition to the scale economies we see the appearance of a product range economy. Flexible technologies permit production in small quantities for small markets, with a variety of products. Idle capacity and equipment obsolescence are reduced; input specifications become more flexible (quality, diversity). There is a drop in working capital (stock of raw materials, products in process, finished products), production is restructured and reorganized. As a result, payments to unskilled labour become less important in the structure of production costs.(6)

The economic crisis in which the region is still emersed has also heavily impacted on investments in science and technology and on the education sector in the vast majority of the countries, creating two dramatic effects. The first is the drastic reduction of all resources allocated to R & D, although resources for basic research and higher education were reduced in even greater proportion than resources for applied research and technology. The second is the immigration of a great number of scientific researchers and engineers to industrially developed countries, particularly the U.S.

The combination of these two effects can be highly dangerous, possibly even more so than capital flight, since the longer the crisis lasts, the more likely it is that those researchers and engineers, and their families, will not return, given that they will have developed deep roots in their new places of residence, and the investment made in them by the developing countries will have been permanently lost. In contrast, financial resources can be repatriated, along with the interest earned, as soon as conditions are ripe.

In the middle of the decade the Academy of Sciences of Latin America had the following to say regarding the region's scientific sector:

"The number of Latin American and Caribbean scientists of recognized international quality is low, and there is a clear lack of specialists in certain areas that are critical for the region.

Recent statistics indicate, for example, that although Latin America has 10% of the planet's population, it contributes less than 1% to world production of science, and that 92% of regional production comes from only five of the region's countries.

"The economic resources allocated by governments to scientific research and technology in the five Latin American countries that produce 92% of the region's science, are five to ten times less in terms relative to national product, which in itself is lower than in the developed countries. For the rest of the countries in the region the amount is less still, or nonexistent.

"Added to the scant resources allocated by the governments to science, in many cases there is also the fact that the allocation of funds to research projects is made without the participation of scientists, and disregarding the fact that the projects must be managed and led by recognized, high- level scientists. This leads to the failure of many projects and the appearance of a class of persons who, while they may have a university degree, are "pseudo-scientists" in the strict sense, since they are lacking in the qualifications of scientists and yet try to exercise the functions of scientists.

"Economic instability, accompanied in many countries by political instability, hinders the growth of the scientific community in Latin America and the Caribbean, leading to the migration of many scientists to developed countries, and making scientific activity unappealing to new generations.

"In many countries, rigidity and the excessively 'professionalizing' structure of higher education systems fail to promote scientific vocations and encumber interaction among the different scientific disciplines.

"Integration and the exchange of scientists among the different Latin American countries is far from reaching an adequate level." (7)

At the end of the '80s, we faced the real and cruel fact of a period of extreme financial limitations and a gradual abandonment of government investments in social and economic sectors. This continues to profoundly affect science and technology, along with higher education. In this decade only Brazil and later Chile managed to increase their investments beyond 1980 levels. (8)

At the same time, we saw the birth of a new wave of technology, a challenge to get beyond the limitations on exports which gave rise to a clear need to create local technology and industrial designs that would be competitive in real terms on the international market.

This new awareness has also awakened the need to reassess the role, somewhat forgotten in the '70s, of science and basic scientific research, not in the linear and Cartesian format mentioned above, but instead as an essential element in the creative whole required of any model assumed for international insertion of the countries of Latin American in the post-Brady Plan future.

Universities have had to be perceived as a resource usable by and for the processes of economic-social development. The universities, in turn, have tried to respond to the challenge not only for financial reasons, but also reasons of a political sort and of image. Thus the borders of basic and applied research begin to disappear, creating intermediary areas where the requirements are of a strategic ilk. This is most visible in the sphere of so-called high technologies, which have "a very basic dynamics," and potential short-term applicability. (9)

III. WHERE ARE OUR SCIENCE, TECHNOLOGY, AND DEVELOPMENT GOING?

F. Sagasti commented that:

"The growing interrelationship between factors of a scientific and technological nature, on the one hand, and those of an economic, financial, social, political, environmental and culture nature, on the other, demand a comprehensive treatment of development policies... It is necessary to give greater visibility to the scientific and technological aspects of the development process; moreover, the efforts to establish and consolidate own scientific and technological capacity in the countries of the region must be seen as a 'national crusade'." (10)

The conflict between the university "ethos" and the business sector is no longer so much so, and we see the reconciliation of interests, perhaps forcibly brought on by the structural, economic change that has come over us. (11) Thus, in this decade, we see the appearance of the "gatekeeper," the "entrepreneur," the leader in the process of linkage between the basic research taking place at universities and the growing demands of the private sector.

The new conditions defined by the overwhelming appearance of microelectronics, informatics and rapid telecommunications, and their influence on the entire development process of the countries, either due to their presence or their absence, obviously also require a new vision of the context in which an advanced technological capacity can be developed in our countries with a real scientific basis. The use of satellite systems to break the incommunication barrier of our scientific communities, along with rapid access to technological information and discussions in other parts of the world, are now possible using instruments based on microelectronics and which are merely an example of what can exist in terms of a new way of organizing what has come to be known as

"networking," the system of interpersonal relations among research, and between researchers and the other actors in the process of linkage at national and international levels.

The transition toward a paradigm of technological information (12) clearly defines new and innovative visions of non-traditional routes for developing countries willing and able to take advantage of the right moment.

Certainly the push into new routes can be more effective if at the same time there can be development of processes of integration among countries of the region such as those so interestingly outlined by the members of the Rio Agreement (G-8). (13)

But in all these future processes we will have to take into account that "science and technology must cease to be an exogenous variable in the processes of economic and social reconstruction"... and that the "search for peace and democracy must necessarily involve... reassessment and promotion of science and technology... as practices committed to the social basis of our countries." (14)

Does the challenge of the '90s imply going back to a "new international crusade"? The answer is definitely not. "Either we invent or we fail" are words as current today as they were when Simón Bolívar heard them from his teacher Simón Rodríguez.

The challenge, domestically, is to deal with the subject of Science and Technology as part of the national strategy, part of the country's project for "economic security," and to act internationally in keeping with that concept. The countries that develop and use their technological capacity as part of their international political strategy will certainly be the ones to see positive results at the outset of the 21st century.

The challenge is for each country to also make use of the paradigms proposed by informatics and biotechnology, but also to find among the ruins of the debt, the will and the need to cooperate with neighboring or sister countries to create partial or total integrations that reinforce their capacity to reach a stage of self-sustained development upon the dawn of a new century, by means of a science effectively linked to development, and a technology truly based on science and at the service of the development of our peoples.

The scientific sector specifically demands concrete steps by governments, such as:

- Supporting public and private organizations promoting or performing scientific and technological research. Government support is especially important now, when the economic difficulties affecting all the countries of the region have led

to an undesirable decrease in the real value of the resources allocated to science and technology.

- Establishing degree programmes for Scientific Researchers in those countries of Latin America and the Caribbean where they still do not exist. Such programmes provide a mechanism for identification and selection of the most competent scientists in each country and favours the stability and appropriate remuneration of same.

- Including researchers having recognized competence in the management of agencies responsible for designing and executing programmes related to science and technology.

- Facilitating the importation, duty- and surtax-free, of equipment, materials and publications for scientific and technological research.

- Promoting funding for grants and devoting existing resources to financing master's and doctoral studies for deserving students and to scientists for forming productive research groups. The amount of grants should permit full-time, exclusive involvement in studies. Post-graduate programmes to be financed should be chosen using the same criterion of excellence. This will avoid dispersion of economic resources and will preserve the good level of training of scientists. (15)

- Investing new resources in Higher Scientific Education and fostering innovative technological production are the only possible routes for future development of the countries of the region.

The study, planning, financing, programming and evaluation of science and technology activities in Latin America face several challenges (6):

1. The need to concentrate efforts. General, horizontal advances in the diverse scientific and technological fields cannot be sought; instead, areas should be chosen for concentration and excellence.

2. Insertion and integration of the science and technology variable in the political processes of defining strategies and decision-making.

3. Scientific and technological activity planning, coordination and promotion agencies should be located outside the spheres of influence of the ministries of education and be directly linked to the ministries of the presidency, finance or planning.

4. The training of intellectual capital, of scientific and technical personnel at post-graduate level.

5. Technological research should stand on two legs:

   a. valuation and upgrading of endogenous technologies; and
   b. adaptation and assimilation of new technologies and of frontier technologies.

6. The strengthening of the process of management and transfer of technology at micro level, of linkage of research to production units. There should be a decrease in emphasis on formal, legal and institutional modes for marketing technology (which is not transfer), as expressed in laws on technology transfer, registration of technology licensing agreements, legal regulation of restrictive clauses in contracts for technology licensing, industrial property, etc. Consequently, there should be a strengthening of technology management and transfer mechanisms geared to small and mid-scale industrial and agricultural enterprises.

7. Improvement of the measuring of scientific and technological activities, the definition and use of endogenous science and technology indicators, and the preparation of detailed diagnoses relevant to decision-making.

8. Strengthening of scientific and technological information services.

9. Strengthening of national consultancy and technical assistance services.

10. Formulation and execution of comprehensive projects for investment in science and technology.

11. Integrated participation of the industrial private sector in the definition of the needs for technological innovation and for investment in S & T.

For multilateral international organizations, the challenge is whether or not to continue setting the pace for the countries. It is necessary to catalyze the initiatives of the member countries, but not to impose ideal multi-agency projects framed by priorities defined by their at times out-moded sectorial structures.

Perhaps the best action programme for the 1990s is to address the priorities of each of the developing countries, and at the same time to support and reinforce the movements and initiatives for cooperation and integration undertaken by them in their different forms, vehicles and time frames.

On its part, the Unesco Regional Office for Science and Technology for Latin America and the Caribbean (ROSTLAC) has raised

several considerations in this regard, which I will point out as a general conclusion to this paper (16):

1. It is fundamental to promote the development of rural zones, disadvantaged populations groups, and to contribute to promotion of the development of women;

2. From the standpoint of science and technology, own strategies must be established, based on the demands generated by the global strategy. Isolated national efforts are not sufficient for triggering the process of sustained development and surmounting the crisis in the short or the long term. Consequently, the global strategy must have a regional dimension. In turn, the science and technology strategy must be geared to the creation of a joint capacity making it possible to reach the proposed objectives and goals in a reasonable time period;

3. A regional science and technology system should also be structured to act as a valid interlocutor with the scientific and technological systems of the more advanced countries. The structuring of such a system implies a sustained long-term effort;

4. The development of scientific and technological capacity also implies the need to initiate immediate actions for surmounting the deficiencies of current scientific and technological efforts, which tend to be:

   a. limited, with a slow growth rate and a short-term vision;

   b. distributed heterogeneously over the countries and within specific sectors;

   c. insufficiently articulated internally between institutions and economic agents;

   d. low level in terms of effectiveness;

   e. insufficiently articulated regionally;

5. The immediate actions that will make it possible to surmount these deficiencies should be geared, among other things, to:

   a. development of the basic sciences;

   b. strengthening of abilities to transfer and assimilate technologies in keeping with the strategies established and the characteristics of the region;

   c. development of assimilation capacities;

d. training very highly skilled scientific and technical personnel;

e. strengthening of the capacities for prospecting, planning, management and assessment of science and technology;

f. strengthening of the national science and technology structures, enabling all countries of the region to fully and fairly participate in the application of regional strategies and the use of their results;

g. strengthening of the capacities for design and application of mechanisms and instruments of science and technology policy;

h. creation and strengthening of financial mechanisms for technological innovation;

i. development of linkages between economic- educational-research agents;

6. The creation of joint capabilities in science and technologies implies moving from the stage of cooperation into that of integration, and thus requires an in-depth analysis of the ways in which this should take place;

7. In compliance with the mandates from the highest political levels in the region, international, regional and bilateral cooperation agencies should intensify their actions so as to aid in achieving the goals of creation of joint scientific and technological capabilities and regional integration.

REFERENCES AND BIBLIOGRAPHY

(1) PRDCYT-OAS.1 "Desafíos de las Políticas Científicas y Tecnológicas y de Institucionalización en América Latina y el Caribe." Internal OAS communication. April 1989.

(2) Enrique Martín del Campo, "La Política Científica y Tecnológica en los Estados Unidos de América." CIENCIA Y DESARROLLO, No. 19. March-April 1978.

(3) PRYDCYT-OAS.1 - ibid.

(4) Francisco R. Sagasti. "Perspectivas futuras de la Ciencia y la Tecnología en América Latina" in "LA TERCERA REVOLUCION INDUSTRIAL-Impactos Internacionales del Actual Viraje Tecnológico" Carlos Ominani, Editor. RIAL, Grupo Editor Latinoamericano 1986.

(5) María Luis Salas de Gómez Gil. "Inventario de la Ciencia y la Tecnología en México." Documentos del INIC. Mexico 1969.

(6) Eduardo Martínez. (1988), La integración de la ciencia y la tecnología en la planificación del desarrollo en Uruguay - Introducción. (UNESCO/OPP, Montevideo, pgs.1-11).

(7) Academia de Ciencias de América Latina - "La Ciencia en América Latina: Situación actual y recomendaciones." Document by the Board of the Academy. April 1984.

(8) PRDCYT-OAS.2. Datos Estadísticos de Ciencia y Tecnología en América Latina. Internal document. August 1989.

(9) Mario Waissbluth. Private communication. July 1989.

(10) Francisco R. Sagasti. "Crisis y Desafío: Ciencia y Tecnología en el futuro de América Latina." Publicaciones de GRADE, Lima, Peru.

(11) Mario Waissbluth, ibid.

(12) C. Freeman and C. Pérez. "Structural crisis adjustment: business cycles and investment behaviour" in G. Dossi, C. Freeman, R. Nelson, G. Silverbert and L. Soete (Eds.), Technical Change and Economic Theory, London, Pinter Publishers, 1988.

(13) UNCSTD. "Development of Science and Technology in Latin America and the Caribbean." Regional review paper, Centre for Science and Technology for Development. United Nations. February 1989.

(14) Manuel Angel Castillo. "Ciencia, Tecnología y Cambio Social." CITGUA A.C. Memorias del III Congreso Latinoamericano sobre

políticas científicas y tecnológicas. San José, Costa Rica. 1-4 March 1988.

(15) Academia de Ciencias de América Latina. ibid.

(16) UNESCO/ROSTLAC. (1988), Reunión sobre la evaluación de conferencias regionales y la cooperación futura de Unesco en ciencia y tecnología - Informe Final (Unesco, Montevideo).