Americans received 0.1% of all patents granted in the EU and 0.2% of those granted in the U.S. This poor show reflects the region's scarce investment in R&D. But the increased rate of investment of the last decade is having an impact here as well: Between 1986 and 1991 the number of all patents granted to Latin American applicants augmented faster than those to U.S. or EU applicants by 28 and 32%, respectively.

A model eyed with interest by Latin American policy-makers are Southeast Asia's "five tigers": Hong Kong, Malaysia, Singapore, South Korea, and Taiwan (*3*). Twenty years ago, these countries invested about 0.1% of their GDP in R&D, by 1981 it was 0.6%, and by 1991 it had grown to 1.6%. Concomitantly, between 1983 and 1991 their share of the world's scientific productivity and patents tripled. The economic consequences are well known: The five tigers have changed from underdeveloped countries to industrialized nations that enjoy high living standards.

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Future of Science in Latin America

Luiz Nicolaci da Costa

The rapid progress of technology and the great achievements of science in this century have produced profound changes in our lives, in the world economy, and in our perception of the physical world. These accomplishments were, however, achieved by a small community, concentrated in industrialized nations. One is left to wonder what could have happened if the full potential of human resources had partaken in this effort. Understanding the reasons for the small contribution to science and technology (S&T) from Latin America is not only of academic interest but essential for promoting the economic and social development of the region. While the role of technology is to a large extent well understood by the governments, the importance of basic research is not. Unless their interconnection is recognized, it is doubtful that a productive system of S&T can be implemented.

In order to understand the dearth of scientific productivity in Latin American countries, it is necessary to review both the origin of the educational and research systems, and the obstacles faced by the scientific communities in the recent past. Most of the difficulties encountered today are a result of the social organization of the countries in the area. These countries are characterized by small dominant elites, strong central governments, oppressive bureaucracies, weak economies, fragile institutions, and unstable political systems. These characteristics largely account for the ineffectiveness of Latin American research efforts. Improvements of the S&T systems in the region will require, above all, fundamental changes in attitudes and administrative habits of the governments, while scientists will have to recognize the need for making realistic decisions regarding new investments.

The author is with the Centre National de la Recherche Scientifique, Institute d'Astrophysique, 98 bis Boulevard Arago, 75014 Paris, France and Observatório Nacional, Rua Gen. José Cristino 77, Rio de Janeiro, Brazil 20921–20.

Origin of Educational and Research Systems

In Latin America, the process of industrialization had a late start, and access to higher education was until recently limited to the upper class. Emphasis was placed primarily on subjects such as literature and law rather than on more technical careers. Few universities were created in Latin America during the colonial period. In Brazil, the first university was formally founded as late as 1920.

Only recently did countries in the region awaken to the importance of developing their own technological capabilities. The foundations for an S&T system were established only after World War II, coinciding with the process of industrialization of major countries in the area. At that time, national research councils were created to coordinate and fund scientific research, and the first research centers were organized to complement the existing university system. In the late 1960s universities were subjected to major reforms and the first graduate programs were implemented.

Period of Growth: The Brazilian Experience

During the economic boom of the 1970s, heavily influenced by the military dictatorship, research in Brazil was reasonably well funded and large numbers of graduate students were sent to study abroad. The main policy goals were to train the necessary personnel for the new graduate programs and to expand the disciplines of research, with special emphasis in strategic areas such as the nuclear and space programs. These investments resulted in a remarkable growth of the scientific community.

On the negative side, several active scientists were forced to leave the country for political reasons, and their absence created a large vacuum in leadership. In addition, no significant effort was made to modernize physical installations or organize local institutes, in preparation for the return of new graduates. These graduates had to face problems such as the lack of office space and inadequate libraries and computer facilities. Instead of concentrating on their research, they had to spend valuable time setting up basic infrastructure. They often had to face resistance to change from the existing senior staff, which controlled the institutes, mostly because of their seniority rather than scientific merit or vision. Ironically, the same government that sponsored the research program prevented the upgrading of the installations through several restrictions on the importation of lab equipment and computers.

Because of the lack of leadership, there was no coordinated effort aimed at modernizing the institutes. Instead, this process had to rely on individual grants, and young scientists had to get immediately involved in fund raising. This condition resulted in an uneven growth of research groups and extremely heterogeneous institutes, ultimately leading to serious power struggles. Not rarely, individuals took precedence over institutions, and a number of institutes were unduly divided. These internal disputes seriously weakened the institutions and jeopardized their ability to define long-term goals and to optimize the local human and financial resources through support of a few well-defined research programs. Instead, research was carried out in a number of fields, none of which had enough scientists to make it internationally competitive.

Serious problems also occurred at the national level (*1*). In some fields, the relatively small number of scientists caused the break-down of the peer review process as considerations other than merit guided the distribution of grants. This practice resulted in intense regional disputes, which generated mistrust and undermined attempts to define common national goals.

Not surprisingly, this period of growth led many recent graduates to get heavily involved in the political maze, to the detriment of their research. Some started participating prematurely in major decisions without the required scientific insight and international experience. Changes in policies, promoted by lobbyist groups, were frequent and usually imposed top-down without the necessary open debate.

Current Status

The internal turmoil within institutions and scientific communities has diverted attention from research work and affected its quality and the quality of the graduate programs. Moreover, this instability led to a growing isolation of the local scientific communities from the international scene. In Brazil, for instance, interaction with the international community has been further jeopardized by travel restrictions and by a ban on the hiring of foreign scientists for federal labs. Such measures have made it difficult for local scientists to maintain international collaborations and to keep up with the fast pace of research abroad.

The difficulties in conducting scientific research became even more acute in the late 1980s with the worsening of the economic crisis and the virtual bankruptcy of major countries in the area. Because federal governments have been the major source of research funding in Latin America, the crunch has essentially brought the whole S&T system to a halt. The persistence of the economic crisis into the 1990s has made the current situation quite dramatic. Extremely low salaries and research funds have provoked a substantial loss of talented technical and scientific personnel, risking the survival of several institutions. A direct consequence of the crisis has been the loss of a long-term perspective as most of the attention has been focused on short-term financial problems.

As a final blow to the stability of the institutions, the process of redemocratization has led support staff and students to demand a stronger participation in running the universities and research institutes. University presidents and institute directors have frequently been selected through elections, which have often turned into popularity contests.

Future Guidelines and Priorities

The future of S&T in Latin America depends critically on the understanding political leaders have of the contributions the system can make to society. While the role of technology for economic and social development is easier to grasp, developing countries usually have a near-term view of the problem and do not appreciate the intertwined nature of the processes of education, basic and applied research, technology, and industry. It must be recognized that advances in technology can only be achieved if certain conditions are fulfilled. First of all, there must exist a commitment from industry to support research and development (R&D). Second, there must be an infrastructure of research universities and institutes, active in basic research, to train new scientists and skilled personnel for these industrial labs and to keep pace with research abroad. Finally, job opportunities for science graduates should be created in the industrial R&D programs. This is the obvious cycle that has yet to be implemented in Latin America. An understanding of the interrelation between industry and basic science, coupled with fiscal incentives to attract investments from the private sector, are the basis for a successful program of S&T. Alternative funding schemes, like debt-for-science swaps, should also be examined in order to attract more resources into the system.

Besides understanding the economic benefits of S&T, the government must also recognize that tangible results will only be achieved in a stable and nurturing environment. This requires stable budgets and institutions, and the revision of current policies that discourage scientific exchanges. Only with stable funding levels will it be possible for each area to adjust its aspirations and regulate its growth in an orderly fashion.

An effort should be made to strengthen the existing institutions, granting them more autonomy and monitoring their performance through periodic evaluations by unbiased international visiting committees. These committees should play a fundamental role in shaping the long-term policies of the institutes and in the recovery of scientific merit as the determining factor in their restructuring. Autonomy will allow each institute to define its own priorities of investments within its allocated budget. At the same time, a deliberate effort must be made to consolidate the existing areas of research. This goal can be accomplished through stronger institutional participation and a more rigorous selection process in granting scholarships.

Furthermore, it is necessary for the scientific community to recognize its financial and human resources limitations and take a more realistic and strategic approach regarding the future. In particular, difficult decisions will have to be made concerning new investments in basic research, especially in the experimental area.

In several fields, the only solution is to conduct research in international facilities. Some disciplines, on the other hand, may justify investments in the region because of logistic considerations. The existence of a resource in the continent such as the Amazon forest, for instance, is a compelling reason to invest in a variety of fields because research in this natural laboratory will lead to unique and exciting results. Areas such as astronomy and geophysics also call for the construction of research facilities in the continent. Access to the southern skies is essential for ground-based astronomy and should be explored. For example, excellent sites for optical astronomy have allowed Chile to host international observatories in its territory, bringing great benefits to the local astronomical community. Radioastronomy would also gain from new installations in the Southern Hemisphere, becoming another possible area of investments by South American countries. There is a great need for the construction of a radio telescope of large collecting area to complement the Arecibo telescope in the north (*2*). Such a project is particularly interesting because it can be carried out by local industries, strengthening the interaction between industry and science and generating local jobs. This would be a world-class facility that could help the local community to leap to the forefront in some research areas. Such large projects should be pursued through international collaborations, which stimulate scientific and technical exchanges, and allow individual collaborations to flourish.

Apart from specific cases, projects are only likely to succeed if they are somehow distinct, have well-defined scientific goals, optimize local human resources, and are not in direct competition with those being carried out in first-world nations. Instead of competing, the aim should be to attract international collaborators. These types of projects are more likely to emerge from individual institutes than from national panels. Institutes should be granted the freedom to pursue them individually or seek collaborators as necessary. Recent developments abroad strongly suggest that within budget constraints of Latin American countries, less costly facilities that allow more focused scientific projects to be carried out are the most competitive.

The task of making scientific research flourish in Latin America is not easy and its consolidation will take time. Several old habits have to be reversed and there are no magical short-term solutions. However, with creativity and common sense, it should be possible to identify areas where world-class contributions can be made.

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