The Universities, Scientific Research and the National Interest in Latin America

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THE MAIN objective of the colonial universities of Latin America from the sixteenth to the eighteenth century was instruction in theology, law, medicine and the arts. Teaching was done by professors whose chairs—*catedras*—still dominate academic work in each field of knowledge in most universities. By and large, during the nineteenth century, the universities developed significantly in numbers of students but less so in other respects.[1] Unlike European and North American universities. Latin American universities have made very limited provision for research. The image of science as a static body of information is still common. The idea of increasing and deepening knowledge through research is still largely alien to them.

The rigidity of the universities became especially evident whenever attempts were made to introduce changes. There were scattered innovations in the internal structure of the universities; the organisation of the university in departments instead of faculties was introduced in the late 1940s and early 1950s in particular schools of certain universities, and it has become fairly common since then. In Brazil, for example, it was introduced after the creation of the University of Brasilia in 1960; Brazilian universities were then reorganised according to the departmental pattern of the universities of the United States. Departments were adopted as the basic units of teaching and research for every branch of knowledge; the "credit system" was introduced; students were enabled to attend the classes of teachers of other departments and schools and to meet students in courses of study other than their own. Another reform integrated the universities physically into single campuses and centralised administrative direction was established.[2] Despite these occasional reforms, the prevailing mode remained one of faculties and professional schools scarcely linked with each other. The universities were not really unitary institutions. They resembled in this respect the French universities as they were during most of the nineteenth century.

In recent decades, despite the lack of qualified teaching staff, there has been a proliferation of universities in Latin America. Research institutes have been established without research workers; grandiose programmes of documentation have been launched by institutions which lack basic collections of scientific and technical journals; agencies for the planning and

[1] Steger, H. A., *Las Universidades en el Desarrollo Social de América Latina* (Mexico: Fondo de Cultura Económica, 1978).

[2] Ribeiro, D., *La Universidad Latinoamericana* (Santiago, Chile: Editorial Universitaria, 1971).

development of research have been created in which the internal bureaucracy absorbs more than 50 per cent of the budget.[3]

Most universities in Latin America lack effective mechanisms for the making of decisions, either on a university-wide scale or even in faculties, departments and professional schools. The central offices often have no reliable information about what is happening in their own universities. Professors have traditionally dominated their chairs, i.e. their junior teachers and assistants, and this situation still obtains in many universities, despite nominal reforms. University senates and other governing bodies are riddled with conflict and intrigue, and they hamper any effective system of university government. The university community is frequently incapable of realistic self-scrutiny.[4]

The greatest defect of Latin American universities is their inattention to their main tasks, which are teaching at an advanced level and the conduct of research. Although over the past 40 years funds for universities have increased—unsteadily—these increased funds have not infrequently been diverted to secondary activities such as transport services, subsidised dining-rooms for students; medical, dental and pharmaceutical services; police and custodial services; and scholarships. Thus, in Venezuela in 1985, while scientific research, teaching, cultural and athletic activities, libraries and extension services received 13.1 per cent of the national university budget, the social and economic services within the university alone came to more than 19 per cent.[5]

The administration of the Latin American universities is top heavy and ineffectual; regulations and procedures overwhelm them and make their functioning difficult. Many of the best teachers, research scientists and technicians spend their time finding a way through the labyrinth of university administration.

Despite the weakness of central authority, or because of it, concerted action within the university on almost any issue is very difficult to attain. All the categories of staff that make up the university—teachers, students, clerical employees and manual workers—interfere, through their various unions and associations, and prevent those who ostensibly have the authority from making decisions. None of them assumes responsibility for leadership; the inferior bodies hamper the actions of the superior ones.

[3] Moravcsik, M., "Local Institutions for the Building of Science and Technology in Developing Countries". Paper prepared for a workshop organised by the United States Department of State through the American Association for the Advancement of Science (Washington, DC: AAAS, April 1979).

[4] Levy, D., "Comparative Perspectives on Academic Governance in Mexico". Paper presented to the Seminario sobre Políticas y Estructuras Universitarias: Antecedentes y Experiencias Internacionales (Viña del Mar, Chile, 21–25 November, 1979); Haar, J., *The Politics of Higher Education in Brazil* (New York: Praeger, 1977); Albornoz, O., "Higher Education and the Politics of Development in Venezuela", *Journal of Interamerican Studies*, XIX (1977), pp. 291–314.

[5] Mendoza Angulo, J., "Sobre el Paternalismo–Populismo en la Universidad venezolana", *El Universal* (Caracas: 28 July, 1985), p. 4–9.

University government may produce, through an occasional coincidence of interests, a clearly formulated decision, but this is relatively rare. Stalemates are more common than unambiguous decisions.[6] The introduction of trade-union tactics brings in criteria of decision which are irrelevant to the nature of the university. These things happen in many universities in Latin America.

There is, moreover, a much older tradition in Latin America of the intrusion of alien considerations into the affairs of universities. This is the tradition of political interference. Such intrusion has been pronounced in countries like Mexico and Venezuela. The penetration of the university by local politicians and political party machines is matched and supported by the political partisanship of members of the teaching staff, who regard such partisanship, manifested in university intrigues, as quite consistent with academic life. The students too are very highly politicised. All these things represent a considerable departure from the ideal of a sober and constructive concern to contribute to national well-being while maintaining academic standards.

Undergraduate Instruction and the Ethos of Research

Efforts have been made in Latin America, with the support of international agencies such as UNESCO, to apply educational techniques which could arouse and stimulate interest in entering a scientific career. As a result of these efforts, the school of chemistry of the Universidad Central de Venezuela—the most important university in the country—instituted an undergraduate programme in chemistry; it was the only one in existence until fairly recently. The programme was conceived, in theory, as providing the training necessary for a career of research in chemistry.[7] Unlike the situation in developed countries, in which the majority of chemists after graduation find employment in the chemical industry, in Venezuela a profession of chemistry scarcely exists. Although the career of a "research scientist"—*investigador científico*—came to be seen by academic chemists as almost automatically following from the *licenciatura* degree in chemistry, this has in fact not happened and has led to much personal frustration. Had the first degree of *licenciado en química* been conceived of as indicating the qualification of a graduate with a general education in chemistry for an appointment in chemical production, a very different arrangement from the one

[6] Latapi, P., "Algunas Tendencias de las Universidades Latinoamericanas: Problemas Relacionados y Perspectivas" (Paris: Joint Research Programme on Higher Education, UNESCO–International Universities Association, ED 78/WS/49, 1978); Moreno, R., "Sindicato Académico contra Universidad", *Pensamiento Universitario*, Mexico, II (May 1977), p. 31.

[7] Vessuri, H. M. C. and Diaz, E., "El Desarrollo de la Química Científica en Venezuela", *Ciencia Académica en la Venezuela Moderna. Historia Reciente y Perspectivas de las Disciplinas Científicas* (Caracas: Fondo Editorial Acta Científica Venezolana, 1984), pp. 305–350.

currently existing in the school of chemistry would probably have been generated. But, given the prevailing academic outlook, this would have derogated the status of the scientist.

Because there is little selection of candidates for admission to the school—resulting from the populistic educational ideals of the 1960s, from the lack of a widely shared, scientific tradition, and a course of study which seeks to train professional chemists ("research scientists")—only a small number of graduates meet the requirements of the course. Even within this limitation, the programme has been less successful than it could have been. For one thing, it has been very difficult to find teachers of chemistry who themselves do chemical research and could therefore serve as models for their pupils. Less than 30 per cent of the teaching staff at the school of chemistry of the Universidad Central are active in research—between 30 and 35 persons—and in the other, even newer, chemistry programmes in Venezuela, the percentage is lower. Of course, there are pretensions to do research which do not correspond to reality; there are groups of teachers who call themselves "research groups", but they never manage to produce anything in the way of research.

One of the outcomes of the failure of the new programmes has been a greater awareness of the difficulties of transplanting patterns of scientific research into a local context. Had there been more such awareness in the early years when the discipline was becoming established as a subject of university teaching, perhaps its institutionalisation would have been more effective as a training for scientists.

Guided by an ideal of rigorous academic research, the teaching programme at the school of chemistry in the Universidad Central de Venezuela was the result of a concern to offer a "good preparation" to the future professional scientist. But since those who planned the syllabus had little experience of research in universities or in industry, they tended to interpret the ideal of a "good preparation" in a way which overloaded the students with information, at the cost of stimulating their creativity and originality. The sheer number of hours in the class-room, numerous theoretical lectures, a great deal of laboratory work, and the system of continuous evaluation on the basis of weekly examinations, gave students no time to think for themselves or to develop their capacity for scientific imagination. Too much rote learning was required of undergraduate students, who were expected to master a body of detailed chemical knowledge more appropriate for a graduate student. As a result, the undergraduate programme in chemistry has normally taken the average student seven years to complete. Although this programme was intended to enable Venezuela to produce its own scientists in this particular field, and to make foreign study superfluous except for unusual cases, it has not worked out. Hence, after the long undergraduate course, some graduates who wanted to follow a professional career in chemical research have thought it necessary to do postgraduate work at foreign centres of chemical research and training.

Mexico

In Mexico a different arrangement has been tried with the same aim, namely, the inculcation into selected undergraduates of the ethos of scientific research.[8] Most Mexican scientists in the biomedical field have obtained their bachelor's degrees in the expectation of entering medical practice; this has entailed the incorporation of a different set of expectations and values from those needed for a career in scientific research. Those who became scientists did so accidentally. At some point in their undergraduate studies, they happened to come into contact with a serious research worker who became their tutor or thesis director. If they persisted under his tuition, they would then undertake graduate training, usually abroad—mainly in the United States—and, after four to six years, would receive a doctorate and return to Mexico expecting to continue work along the lines of the research for their dissertation. This was not always feasible: the appropriate conditions and laboratory facilities were generally lacking. The result was a noticeable decrease in the quantity and the quality of scientific work.[9] A period of adjustment of variable length was necessary before the new doctor could find himself at home in the Mexican scientific environment. This adjustment often ended in sterility.

In 1973, a group of scientists at the Instituto de Investigaciones Biomédicas of the Universidad Nacional Autónoma de México undertook to develop a new kind of undergraduate programme designed exclusively to train a young elite for scientific research. As they saw it, the role of the research scientist could only be established in Mexico through a new training programme.

One basic problem of the undergraduate training of future scientists in Latin America is how to induct these future scientists into the ethos of research of a functioning scientific community; the problem is made much more difficult when the solution has to be sought in the setting of a mass university. The absence of opportunities for their employment as scientists in industry, government laboratories and research centres, or in universities, has a discouraging effect. So does the still strong tradition that a university degree is a step towards a career in a practical profession such as medicine or engineering.

Postgraduate Studies in Latin America

International institutions have been active in efforts to improve higher education in science in the region. Scholarships have been awarded for study

[8] Lomnitz, L. and Fortes, J., "Socialization of Scientists: the Ideal Model", Mexico: UNAM, 1983 (mimeograph).

[9] The problems of readjustment of the Mexican scientist when he returns from his postgraduate training abroad are also discussed in Rodriquez Sala-Gomezgil, M. L. and Chavero Gonzalez, A., *El Cientifico en México: su Formación en el Extranjero, su Incorporación y Adecuación al Sistema Ocupacional Mexicano* (Mexico: UNAM, 1982), pp. 69–170.

abroad by the United States Agency for International Development and bodies like the private philanthropic foundations of the United States; for example, in the field of medical research, the Rockefeller and Kellogg foundations, among others, and in engineering and the social sciences, the Ford and the Guggenheim foundations. The Fulbright Foundation is another organ of the United States government that also provides scholarships for study in that country. Other governments and international and regional agencies like UNESCO and the Organisation of American States contribute to the training of university teachers. Parallel to these international efforts, increasing funds have been provided by the governments of Colombia, Venezuela, Mexico, Brazil, and other countries. These have generated a flow of postgraduate students from the Latin American countries to the main scientific centres of the United States and Western Europe, which has resulted in the local implantation of certain bodies of knowledge.

Foreign training has not, however, been sufficient to implant a tradition of fruitful research in Latin America. Many a young scientist who has returned to his country convinced he was capable of developing there as a research worker, soon began to feel the frustration caused by the lack of a scientific tradition and absence of intellectual interlocutors, auxiliary staff and serious, hard-working students.

The exertions of the pioneers of science policy in Latin America to raise the level of quality and the productivity of scientific research by reform of their universities have not been successful. Why have so few universities managed to be productive, despite the fact that many departments, faculties and schools of Latin American universities are now staffed to a substantial extent by holders of the degrees of Ph.D. and M.Sc.? Many reasons for the failure have been adduced: the absence of a scientific tradition, the greater rewards for political or administrative careers, the lack of mutual stimulus, the non-competitive appointment of teachers, social snobbery, the unconnectedness of research with possible users in industry—and even the absence of potential industrial users—the hierarchical attitudes of the senior teachers and the suppression of aspiring young scientists by their elders.[10]

In a continent with well-equipped schools of physiology, pharmacology and biochemistry, no relevant schools of microbiology or genetics have been developed. Both these disciplines are crucial for the solution of problems in agriculture and health. For 20 years from 1950 to 1970, Mexican diosgenin—a sapogenin derived from barbasco, a species of *Diascorea* traditionally used by peasants as a fish poison—was the dominant starting material for the world production of steroid drugs. However, as late as 1979, Mexico did not

[10] Two classic statements of the lag in Latin American scientific development are Herrera, A., *Ciencia y Política en América Latina* (Mexico: Siglo XXI, 1971), and Jaguaribe, H., "Por qué no se ha desarrollado la ciencia en América Latina", in Sábato, J. (ed.), *El Pensamiento Latinoamericano en la Problemática Ciencia-Tecnología-Desarrollo-Dependencia* (Buenos Aires: Paidós, 1975)

produce a single gramme of corticosteroid because it had failed to master the microbiological technology for the oxygenation of progesterone in carbon II; this was developed by Upjohn in 1956. Conservation of meat and the industrial handling of wool and leather, require a deep knowledge of the constituent globular and fibre proteins. But Argentina has not developed an important body of scientists in the scientific disciplines related to agriculture, and the reason for this failure is a significant element in the understanding of the history of science at the periphery. There were no scientists working on the chemistry and physical chemistry of muscle proteins, collagen and keratin, despite the fact that the export of cattle products generated, for many decades, a considerable part of the wealth of the country. Biology, as traditionally practised, was an intellectual endeavour without any interest in its practical implications. Scientists were rarely asked to solve industrial, military or medical problems. The technological solutions needed were obtained by importing them from abroad.[11]

A problem may be of critical importance for a country at the periphery, but it tends to await solution until scientists, technologists and business men at the centre invest effort and money to provide the technological solutions needed by the peripheral country. Even in the most productive groups, the intellectual burden of peripherality is clearly visible. Frequently, those branches of science which are most developed in a Latin American country, and which are closer to the point where they could cease being imitative of work at the world centres of science, are the least related to practical economic problems.

Nevertheless, efforts to attain a greater measure of scientific independence have continued. The development of programmes of graduate studies in Latin American universities was one such effort. More than 80 per cent of the postgraduate programmes currently in operation were created in the 1970s and 1980s. They were usually conceived as a means of producing teachers of science and scientists who could render Latin American scientific research capable of dealing with the practical problems of their various societies.

Scientific achievement and higher education are not the same. There is sometimes a conflict between the science policy of a country and its higher educational policy. For example, the creation of mass universities has certainly not been conducive to scientific achievement. The democratic aim of higher education which led to the mass universities has clearly been in conflict with the development of centres of high scientific achievement in the universities themselves. The former abhors selective admission, the latter requires it. The Latin American postgraduate programmes of the last decade are efforts to resolve this conflict.

[11] Goldstein, D., "El Desafío Biotecnológico: Ser o no Ser como Eduardo S. Bradford", *Interciencia*, IX (July–August 1984), pp. 186–187.

Many of these courses of postgraduate studies have succumbed to an extant tradition of Latin American universities and confined themselves to teaching. Students may still earn postgraduate degrees without doing any research.

In order to break with this tradition, efforts have been made to create a stimulating atmosphere for research within the universities by imposing a complete separation between the members of research institutes and the teachers of undergraduate students within the same university. This has been the case of the research institutes at the Universidad Autónoma de México (UNAM) and the Centro de Investigaciones y Estudios Avanzados of the Instituto Politécnico Nacional, also in Mexico.[12] Although some members of the institutes occasionally give a course of lectures to undergraduates, there is no regular collaboration between the institutes and the undergraduate departments. But this separation—an attempt to preserve excellence, by concentrating it within the institutes—has injurious effects not only on the teaching staff but also on the research workers themselves. It produces graduates of poor quality from the mass undergraduate schools and limits the better qualified teachers to the teaching of very small groups at the postgraduate level. This in turn restricts the number of capable graduate students available for postgraduate study, and hence the future supply of scientists.

There are also cases in which the opposite occurs. The postgraduate programme in some universities does not have sufficient independence from the undergraduate school. There is a single budget for the entire faculty or school where both undergraduate and postgraduate programmes are taught. The teachers in the postgraduate programme belong to a particular faculty which is responsible for teaching undergraduates. The demands on the research worker who has to teach both undergraduates and postgraduates are numerous and burdensome and leave him with insufficient time and tranquillity to concentrate on his own research or on the supervision of research in the postgraduate programme. Frustrations of this kind are frequent in some Venezuelan universities. Another consequence is that some of the better qualified and ambitious teachers provide teaching for undergraduates which is inappropriate to their level of preparation; it is often too advanced because the scientist who wishes to do research cannot adjust himself to teaching at an elementary level. This may happen as a result of a young teacher's desire to share some of his own intellectual experience from his own period of doctoral study abroad with an audience of undergraduates who cannot profit from it.[13]

An adequate supply of doctoral and postdoctoral students is a basic precondition for the scientific achievements of universities in the countries

[12] A version of the life-story of a typical Mexican research worker can be found in Carvajal, R. and Lomnitz, L., "Postgraduate Science Fellowships in Mexico and the Development of the Scientific Community", *Interciencia*, IX (September–October, 1984), pp. 270–274.

[13] Vessuri, H. and Diaz, E., "El Desarrollo de la Química Científica en Venezuela", *op cit.*

which form the centre of the international scientific community.[14] By contrast, the supply of postgraduate students in Latin America is very low. In 1980, Latin America, with a population of 364,660,000, had 90 million young persons in school, of whom 7,470,000 were in higher education and only about 67,000 were registered in postgraduate programmes. This means that in Latin America there were 18.6 postgraduate students for each 100,000 inhabitants and 1 per cent of the total were in higher education (Table 1). These figures are extremely low in comparison with the United States which has a million-and-a-half postgraduate students, amounting to 642 advanced students for every 100,000 inhabitants—35 times more than Latin America—and 13 per cent of all students in colleges and universities.

Of course, institutional and financial provision for postgraduate studies in itself is no guarantee of an effective training for productive scientific work. In Latin America, only a few of the programmes of postgraduate studies rise to a reasonable level of quality.

Colombia, with 26.79 postgraduate students per 100,000 inhabitants—a rate almost 8 per cent higher than that of Argentina—has no provision for training at the doctoral level.[15] In Colombian universities, only a minority of teachers hold postgraduate degrees. In agronomy and related fields, they form 31.6 per cent of the teaching staff; in fine arts, 37.3 per cent; in educational sciences, 27 per cent; in health sciences, 56 per cent; in social sciences and law, 23.1 per cent; in economics and related fields, 23.1 per cent; in the humanities, 35.7 per cent; in engineering and related fields, 21.7 per cent; and in mathematics and natural sciences, 38.1 per cent.

In Argentina, the continental European—particularly the German—pattern was followed, with the doctorate being the normal culmination of study at a university. The Germanic pattern also entailed training in research so that earlier in the century Argentina produced a considerable number of competent scientists. However, this tradition has fallen into decay and Argentina now lags behind some other Latin American countries in provision for the training of scientists.[16]

Brazil has at present an extensive calendar of courses leading to the master's degree; it covers practically all fields of knowledge. Government bodies, like the Coordenação de Aperfeiçoamento do Pessoal de Nível Superior (CAPES) and the Conselho Nacional de Desenvolvimiento Científico e Tecnológico (CNPq), attempt to raise the level of training of the population through the co-ordination and support of courses of study leading to higher degrees; only rarely do these agencies grant scholarships for studies abroad.[17] The current enrolment in postgraduate courses is

[14] Morles, V., "Los Estudios de Postgrado en América Latina: Visión Panorámica", *Interciencia*, VIII (January–February, 1983), pp. 23–30.

[15] Paez, E., "Se Justifica el Doctorado en Colombia?", *Colombia: Ciencia y Tecnologia*, III (February–April, 1985), pp. 12–14.

[16] FLACSO-Programa Buenos Aires, *La Educación Superior en Argentina* (Caracas: CRESALC–UNESCO, 1985).

[17] Pontes, H., *La Educación Superior en Brasil* (Caracas: CRESALC–UNESCO, 1985).

TABLE I
Graduate Students in Latin American Universities, 1980

Countries	Total Population	Population in school	Students in higher education	Graduate students	Number of postgraduate students per 100,000 inhabitants	Graduate students as percentage of total students
Argentina	27,300,000	6,888,000	858,000	5,200	19.05	0.61
Bolivia	6,456,000	3,990,000	90,180			
Brazil	125,500,000	31,126,000	2,546,000	12,000	9.56	0.47
Colombia	28,000,000	8,372,000	455,000	7,500	26.79	1.65
Costa Rica	2,400,000	741,700	66,000	600	2.50	0.91
Cuba	10,500,000	4,674,000	241,000	700	6.67	0.29
Chile	11,100,000	3,301,000	263,700	1,800	16.22	0.68
Ecuador	8,470,000	2,033,000	33,100	150	0.81	0.45
El Salvador	4,400,000	1,496,000	123,000			
Guatemala	6,800,000	1,228,000	49,000	450	6.62	0.92
Haiti	5,980,000	586,000	5,200			
Honduras	3,550,000	871,800	27,500			
Mexico	71,910,000	7,032,000	1,466,000	31,000	43.11	2.11
Nicaragua	2,500,000	557,600	28,500			
Panama	1,850,000	723,600	71,400	60	8.65	0.22
Paraguay	3,200,000	648,800	34,300			
Puerto Rico	3,500,000	830,900	108,850	360	10.26	0.33
Peru	17,800,000	6,074,000	218,700	700	3.93	0.32
Dominican Republic	5,300,000	1,451,000	83,300	90	1.70	0.11
Uruguay	3,150,000	614,400	53,900	350	11.10	0.65
Venezuela	15,000,000	4,208,000	644,600	6,200	43.33	0.96
Total	364,666,000	87,447,800	7,469,530	67,160	18.60	1.00

SOURCE: Figures estimated on the basis of: UNESCO, *Statistical Yearbook* (1978–79), (Paris: UNESCO 1980); UNESCO *Evolución Cuantitativa y Proyecciones de Matrícula de los Sistemas Educativos de América Latina* (Paris: UNESCO, 1979), and the official bulletins of some countries. Table from Morles, V., "Los Estudios de Postgrado en América Latina: Visión Panorámica," *Interciencia*, VIII (January–February 1983), pp. 23–30.

28,000 students; 24,631 of them are studying for the master's degree and 3,669 are following doctoral programmes.[18]

Venezuela has had a rapid growth in postgraduate work, as well as a programme of foreign scholarships to train scientists and engineers for research. The number of research workers with postgraduate degrees in 1981, according to the Venezuelan Consejo Nacional de Investigaciones Científicas y Tecnológicas (CONICIT), was 2,095, out of a total number of research workers estimated at 3,464—about 60 per cent. By 1978, there were 263 postgraduate programmes in different subjects in Venezuelan universities, in 1981 more than 300, and by 1984 they had reached 363.[19] As in the other Latin American countries, the most important universities and government agencies are trying to raise the quality and thus to offer valid alternatives to study abroad. So far, the universities have absorbed a large proportion of these graduates. Public and private administration have also become employers of graduates with the master's degree. A postgraduate degree is rapidly becoming a prerequisite for many types of appointment.

There has also been some regional provision of postgraduate programmes in different subjects; these include the Facultad Latinoamericana de Ciencias Sociales (FLACSO), the Instituto Latinoamericano de Planeamiento y Estudios Sociales (ILPES), the Instituto Interamericano de Cooperación Agrícola (IICA) and the Consejo Latinoamericano de Física (CLAF), which are non-governmental organisations—with the partial exception of the Instituto Interamericano which is dependent on the Organisation of American States and hence falls thus within the category of intergovernmental agencies. They receive students from all over the region for postgraduate courses of study of varying lengths, normally supporting them through scholarship programmes.[20]

The Cuban arrangement for postgraduate studies differs from that of the rest of the countries of Latin America. It began in 1975, when there were about 100 persons with doctorates. In that year, it was decided to establish postgraduate education as a responsibility of the Ministry of Higher Education; a distinction was made between a system of *grados científicos* (scientific degrees) and the *sistema de superación profesional* (professional improvement programmes). The training for scientific degrees began in 1977; admission to it is highly selective. It grants two degrees: the *candidato a doctor en ciencias* equivalent to the Ph.D., and the *doctor en ciencias*, the highest scientific degree, which is awarded after defending before a jury of scientists a work adjudged to be a substantial contribution to the branch of

[18] *Ibid.*

[19] Hernàndez, A. G., "Hacia la Acreditación de los Postgrados Nacionales. Educación, Ciencia, Sociedad" (Caracas: Consejo Consultivo Nacional de Estudios para Graduados, Consejo Nacional de Universidades, 1984).

[20] Morles, V., "Los Estudios de Postgrado en América Latina: Visión Panorámica", *Interciencia*, VIII (January–February 1983)), pp. 23–30; Schkolnik, S., "Los Estudios de Postgrado en América Latina y el Caribe: fase II: Algunos Proyectos Regionales. Informe final", Caracas: CRESALC–UNESCO, 1981 (mimeograph).

knowledge in question. The M.A. does not exist as a scientific degree in Cuba. In 1984 there were more than 1,600 professionals with scientific qualifications, i.e., the *candidato a doctor* or the *doctor*.[21]

The second stream of postgraduate study—*sistema de superación profesional*—is broader in scope; it is intended to supplement and bring up to date the knowledge of practising professionals in various fields. Current enrolment in a single year is more than 30,000. It takes several forms. The *curso de postgrado* (postgraduate course) may consist of up to 120 hours of lectures; over 1,500 postgraduate courses of this type are taught every year. A second type of training programme within this system of *superación profesional* is the *estudio de postgrado*, which consists of 160 to 500 hours of lectures. A third type is the *entrenamiento de postgrado*, a specific project carried out by a professional during a period at a research or labour centre, with the purpose of improving knowledge and practical skills in a particular discipline: this training may last about one year with full-time participation, either in Cuba or abroad. Finally, the *programa de especialización profesional* is a complex, prolonged course of study which entails, particularly in the medical sciences, training in a new field of specialisation. As a full-time course, it involves the continued practice of the profession with the transfer of the person so trained into a new speciality at the end of the course. It takes from two to five years of full-time work.[22]

National Scientific Communities: Their Relations with Government and Society

In many Latin American countries, during the first half of the century, such research as was carried out was not done in the universities. It was done in governmental institutes and departments, in fields like tropical medicine, agriculture, virus disease, anti-ofidic serum and vaccines. A few institutes produced significant work despite unfavourable local conditions.[23] In a very few universities, in Buenos Aires, La Plata and the Universidad Autónoma de México, there were small research groups or individuals, often made up of European immigrants. These managed somehow to develop active scientific enclaves within the stagnant universities.[24]

[21] Departmento de Estudios para el Perfeccionamiento de la Educación Superior, Universidad de la Habana, *La Educación Superior en Cuba* (Caracas: CRESALC–UNESCO, 1985), pp. 36–39.

[22] *Ibid.*

[23] The social history of the founding and maintenance of the institutions of science in Latin America in the nineteenth and twentieth centuries has still to be written. A notable exception is Stepan, N., *Beginnings of Brazilian Science: Oswaldo Cruz, Medical Research and Policy, 1890–1920* (New York: Science History Publications, 1976).

[24] An interesting exploration of the early implantation of physical and mathematical research in an Argentinian university is that of Pyenson, L., "*In partibus infidelium*: Imperialist Rivalries and Exact Sciences in Early Twentieth-Century Argentina", *Quipu*, I (May–August 1984), pp. 253–303. There is also an account of the antecedents of atomic energy in Argentina in Mariscotti, M., *El Secreto Atómico de Huemul* (Buenos Aires: Sudamericana–Planeta, 1985).

After the Second World War, there was a growing awareness in some circles in Latin America that successful research depends to a certain extent on scientific communities which sustain the individual scientist with stimulation and encouragement. Without the use of the term scientific communities, a handful of universities have shown a moderate degree of sensitivity to this aspect of scientific work. They have recognised that concentration on undergraduate teaching and professional training does not produce scientific achievements. The potentialities for the formation of local and national scientific communities have been nurtured by the adoption of arrangements for full-time teaching, the acquisition of a doctorate in a central country by a significant number of teachers, the construction and modernisation of laboratories and other installations for experimental work, the adoption of departmental patterns whereby a number of teachers in the same or closely related fields of science—previously dispersed and isolated in large faculties or separate schools within the same university—were brought together into single departments, and the acceptance of the principle that teaching and research were to be combined as inseparable parts of the academic career.

Rudimentary scientific communities were formed in some Latin American countries, as their small numbers of scientists developed a collective consciousness of themselves as scientists, and became collectively critical of certain political changes taking place in their countries. Various Latin American governments have tried to subject the universities to their control, partly in response to student agitation and partly in reaction to their scientists who were acquiring a critical attitude towards politics. The tradition of university autonomy, inherited from Europe, came into confrontation with political authority. This is certainly not entirely attributable to the incipient formation of scientific communities, since it arose originally out of conflicts between students and the police. The tension between the incipient scientific communities and the governments of their respective countries also has sources in two attitudes intimately connected with the very fact of their growing collective consciousness. As they became more imbued with their sense of being scientists they also became aware of the importance of scientific knowledge in the creation of modern societies in Europe and North America; they became more critical of their rulers for not moving in that direction. They thought that if their governments were less exclusively concerned with their own power, they would be able, through the contribution that scientists could make to modernisation, to improve the life of their own societies and bring it closer to the pattern of the central societies. They became more sensitive to the gap between what their rulers were in fact doing and what they could do if they acted more "scientifically". At the same time, the scientists of Latin America, at least the more thoughtful ones, were becoming acutely aware, from their experiences at home and abroad, that their own scientific achievements were deficient. They concluded that action must be taken to remedy this situation. The

remedy they saw was, on the one side, the improvement of basic scientific research in their own countries, and on the other, the financial support of government as a precondition for this. Nationalistic and anti-imperialistic attitudes, which were becoming even more pronounced among Latin American intellectuals in this period, sharpened these convictions. They were also becoming more conscious of the deplorable state of their universities.

A number of consequences followed. Basic and applied research were established in specialised centres or institutes, both within the universities and outside them. The Instituto Venezolano de Investigaciones Cientificas (IVIC), El Colegio de México, the Fundación Bariloche and the Universidade de Brasilia were among those new institutions.[25] They were established by scientists who had become convinced that their programme of implanting a tradition of serious scientific research in their countries could only succeed if they took such independent action; they thought that this was the only way to protect scientific activity from the distractions of the local political and cultural situation. In order to ensure that the work done in these institutions would be of high quality they demanded that the collaborators whom they appointed to the institutions should have master's degrees or doctorates obtained in foreign universities. They saw such requirements as the only way to produce scientific work worthy of acceptance by the international scientific community.[26]

This emphasis on the quality and the fundamental character of the research they did or sponsored brought them into conflict with the demand for practical economic utility, espoused by governments through their different agencies, and also by the politically committed members of the scientific communities.

These various aspirations and demands were not quite harmonious with each other. On the one side, the desire for basic or pure research was coupled with the demand that the problems of research should be freely chosen by the scientists who were to do the research. On the other, the desire for national economic growth and the associated requirements that research should serve that end were bound to come into conflict with the demand for freedom in the choice of problems. The conflict was not resolved by the assumption by central governments of responsibility for the financial

[25] See Lomnitz, L., "Hierarchy and Peripherality: The Organisation of a Mexican Research Institute", *Minerva*, XVII (Winter 1979), pp. 527–548.

[26] Several authors have explored the antecedents and actual process of the transfer and local development of scientific activity in particular countries of the region. See, e.g., Schwartzman, S., *Formação da Comunidade Cientifica no Brasil* (Rio de Janeiro: FINEP–Editora Nacional, 1979), and Scwartzman, S., "Struggling to be Born: The Scientific Community in Brazil", *Minerva*, XVI (Winter 1978), pp. 545–580; Schoijet, M., "The Condition of Mexican Science", *Minerva*, XVII (Autumn 1979), pp. 381–412; Vessuri, H. (ed.), *Ciencia Académica en la Venezuela moderna*, *op cit.*, and Vessuri, H., "The Search for a Scientific Community in Venezuela: From Isolation to Applied Research", *Minerva*, XXII (Summer 1984), pp. 196–235.

support of scientific and technological research. The conflicts between scientists and their governments were in fact aggravated by governmental policies which opened the way for foreign investment and for the entry of "multinational" firms. Devoted though these ambitious scientists were to the standards of the international scientific community, they were also fervent nationalists. They thought that as well as exploiting their countries, the multinational firms were preventing science from developing at the periphery by concentrating the research they desired in their own countries. On grounds of nationality and science, they have often been very censorious towards their governments, whom they have accused of not caring sufficiently for "the national interest". The governments have for their part frequently responded in kind.

The Latin American governments are not entirely without regard for the representations of the scientists. In many of the countries governments have created national councils of science and technology for the promotion of scientific and technological research; the control of these councils has been shared by scientists. Latterly, however, governments have tried to exercise the preponderant power in these bodies.[27]

Nevertheless, the influence of scientists on the science policies of the Latin American governments has been considerable. One manifestation of this influence was the decision of Argentina when, in 1961, it established within the Consejo Nacional de Ciencia y Técnica (CONICET), created in 1957, institutional arrangements for the *carrera del investigador*—professional research worker. The current structure of this system comprises five categories, from *investigador asistente* to *investigador superior*. The *carrera del investigador* provides a guarantee of relative academic freedom and stability, because the scientist who manages to enter the *carrera* has a full-time appointment, and if necessary, the Consejo Nacional, through the mechanisms of the *carrera*, gives him or her supplementary funds to ensure an adequate level of remuneration. The provision made for the assessment of scientific achievement by peers protects the research worker from political arbitrariness.[28]

During the recent military regime in Argentina, approximately 150 research institutions of very unequal quality were created by the Consejo Nacional de Ciencia y Técnica; it did not provide for research at the universities and other governmental and non-governmental institutions. From being an agency for the promotion of scientific research, the Consejo Nacional became an agency for the conduct, execution and administration of projects within its own centres. The new democratic government is

[27] Amadeo, E., "Los Consejos Nacionales de Investigación en América Latina: Éxitos y Fracasos del Primer Decenio", *Comercio Exterior*, Mexico, XVIII (1978), pp. 1,439–1,447; Brawerman, J. and Novick de Senen Gonzalez, S., *Los Organismos Centrales de Política Científica y Technológica en America Latina* (Washington: OAS, Department of Scientific and Technological Affairs, 1980).

[28] UNESCO, *Consulta Latinoamericana sobre la Situación de los Investigadores Científicos. Informe Final* (Montevideo, Uruguay: UNESCO, SC-81/Conf.202/Rwef.7, June 1981).

seeking to reestablish the support and promotion by the Consejo Nacional of research of groups of scientists in institutions other than those it founded itself. Again, efforts are being made to guarantee the application of strict scientific standards in the assessment of achievements and purposes.[29]

In Brazil—one of the countries that has made the greatest efforts to finance and organise scientific and technological research—governmental support of research is carried out mainly by the Financiadora de Estudos e Projetos (FINEP), which is an organ of the Secretaría de Planejamento of the President's Office, and by the Conselho Nacional de Desenvolvimento Científico e Tecnológico; both agencies help pay for equipment, materials, books, services, technical staff and supplementary salaries through research scholarships for university teachers and government employees engaged in research.

The government of Venezuela has supported the small amount of scientific activity undertaken in that country during the last 25 years, basically through the maintenance of the Instituto Venezolano de Investigaciones Científicas (IVIC)—one of the few centres of excellence in Latin America and one which has been active since 1959—and more recently through the Consejo Nacional de Investigaciones Científicas y Tecnológicas (CONICIT), created in 1967. Venezuela is one of the small number of Latin American countries with relatively well-organised provision for the proper equipment of laboratories, financing of travel to international symposia and conferences, "research apprenticeships", advanced training abroad for members of staff of the national universities, and sabbatical leaves for research by academics. Although there is no government guarantee of permanent tenure for research workers as in the Argentinian *carrera del investigador*, and although the current economic crisis threatens to undo the advances made to date, the Venezuelan national universities have managed to have a large proportion of their teaching staffs working in full-time appointments. The Universidad Central—the Venezuelan university with the largest number of research workers and research projects in the country—receives 43 per cent of the total number of research grants made by the Consejo Nacional de Investigaciones Científicas y Tecnológicas. Although the absolute figures continue to be very small, the Universidad Central received 359 grants out of a total of 835, awarded between 1970 and 1984.[30]

The universities of Colombia perform about 26 per cent of all the research done in that country by government agencies and universities, but the universities themselves have to pay for nearly half of it—46 per cent—from their own budgets. Governmental bodies contribute 32.1 per cent of the

[29] Personal communication of the president of CONICET, Dr C. Abeledo, December 1984.

[30] Machado Allison, C. and Febres de Faillace, L., "Evaluación de los Proyectos Financiados por el CONICIT a Investigadores de la Universidad Central de Venezuela (1970–1984)", Caracas: CONICIT, May 1985 (mimeograph).

cost of academic research and foreign institutions 21.9 per cent, the latter mostly in the fields of health and agriculture.[31]

Mass Universities: The Demographic Legacy of the Recent Past

Since the 1950s, the student bodies of Latin American universities have, like those elsewhere, expanded greatly. University attendance rose from 3.6 per cent of the population between 18 and 23 years of age in 1965, to 11.5 per cent in 1977. From 1970 to 1975, the student bodies of the universities grew at an annual rate of 17.6 per cent, while the rate of growth of the Latin American population as a whole was 2.9 per cent per annum. The rate of growth of the student bodies was even higher in the larger countries, such as Argentina, Brazil and Mexico.[32]

Patterns of growth have not been uniform. Thus while Brazil, Mexico and Venezuela had their period of greatest growth between 1965 and 1970, Argentina, Colombia, Chile and Cuba had theirs between 1970 and 1975. In the period from 1955 to 1970, the university student body in Venezuela grew by 2,083 per cent; it was followed by those of Colombia which increased by 1,305 per cent, Brazil by 983 per cent, Chile by 722 per cent, Peru by 591 per cent, Mexico by 453 per cent, Cuba by 280 per cent, and Argentina by 249 per cent.[33] The lower rate of growth of Argentina can be explained by the fact that its expansion occurred earlier than that of the other Latin American countries.

In the 1950s and 1960s, an unsuccessful attempt was made to control the growth of demand for places in the university; an alternative policy of concentration on the training of the technological and cultural elite was pursued. The middle classes, made up of practitioners of the learned professions, technologists and higher civil servants, dependent on government for employment and other benefits, wished to have the universities reserved for their own offspring and for persons who would be like them.

In the 1970s, however, it was decided in most Latin American countries to "democratise" higher education.[34] This meant making the universities accessible to the offspring of sections of the population who previously had been unable to attend them. As a result, masses of degree-holders flooded a labour market which had not expanded sufficiently to receive them. While the graduates of public universities were unable to obtain employment,

[31] Parra Sandoval, R. and Jaramillo, B., *La Educación Superior en Colombia* (Caracas: CRESALC–UNESCO, 1975).

[32] Segal, A., "Higher Education in Latin America and the Caribbean: An Overview", *Interciencia*, X (July–August 1985), pp. 196–198.

[33] Sagasti, F., Chaparro, F., Paredes, F. and Jaramillo, H., *Un Decenio en Transición: Ciencia y Tecnología en America Latina y el Caribe durante los Setenta* (Lima: GRADE, March 1983).

[34] Rama, G., "Condiciones Sociales de la Expansión y Segmentación de los Sistemas Universitarios", in Rama, G. (ed.), *Universidad, Clases y Poder* (Caracas: CENDES/Ateneo, 1982), pp. 89–90.

some private universities adapted themselves to the small number of opportunities in modern industries and commerce—often foreign in ownership—by providing the specialised training required for such appointments. In consequence, the private universities grew rapidly. The public universities sought to improve themselves by instituting "staff development" programmes to provide better qualifications for a large number of teachers of scientific subjects.[35] The programme was doomed to failure. So many teachers were required for the vast numbers of students that it was impossible to appoint enough of sufficient intellectual capacity; the programmes of "staff development" could not cope with the situation.

In countries under authoritarian regimes, efforts began to reduce the number of registered students. Chile reduced its total enrolment of university students between 1973 and 1976 from 145,000 to 134,000 students. The places offered by the Chilean universities declined from 100,000 in 1972–73 to 85,599 in 1974–75 and to 67,862 in 1976–77.[36] In Argentina, the military government applied a similarly restrictive policy to university admissions between 1977 and 1983. In 1977, the number of new students stood at 90,000; in 1983, it was less than 45,000. The total student body in Argentinian higher education, which in 1976 had reached 518,116 students, fell to 393,828 in 1980.[37] With the return to democracy in Argentina, there was a sudden surge in the numbers of admissions. In the Universidad de Buenos Aires alone over 92,000 new students were admitted in 1984 to the first year of the university.

Even with these restrictions, the Latin American universities have remained mass universities. To deal with this situation and the resulting unemployment of graduates, attempts have been made to divert the student body into specialised courses of study of varying lengths and quality, leading to degrees and diplomas of different status.[38] The decline in quality of the education offered in these universities[39] went hand in hand with the increase in the ratio of students to teachers. In the Peruvian universities in 1960 there was an average of 8.5 students per teacher; in 1970 this figure had reached

[35] Graciarena, J., "Esbozo de Interpretación de la Crisis Actual de la Universidad Latinoamericana", in *ibid.*, pp. 38–39.

[36] Schifelbein, E. and Grossi, M. C., *Análisis de la Matrícula Escolar en Chile* (Santiago: CIDE, Working Paper 10578, 1978), p. 52, quoted by Bruner, J. J., "Universidad, Cultura y Clases Sociales en Chile: la Formación de las Elites". Graciarena, J. *et al.* in *Universidad y Desarrollo en América Latina y el Caribe* (Caracas: UNESCO–CRESALC, 1984), pp. 71–88.

[37] *La Educación Superior en Argentina*, *op. cit.* See also Alvarez Rojas, F. E., "La Educación en Argentina", *Interciencia*, IX (July–August 1984), p. 231.

[38] Bronfenmajer, G. and Casanova, R., "Proposiciones sobre la Universidad Venezolana: Radicalización Política, Diferenciación y Polarización Ideológica en el Contexto de Dominación Democrático-Burguesa y Capitalismo Dependiente", in Rama, G. (ed.), *op. cit.*, p. 273.

[39] See, e.g. Schwartzman, S., *Ciencia, Universidade e Ideologia* (Rio de Janeiro: Sahar, 1981), esp. pp. 96–127; Vessuri, H. "La Calidad de los Postgrados Nacionales: Estándares y Responsabilidades de la Comunidad Científica", *Planiuc* (Valencia), III (January–June 1984), pp. 147–160; Moravcsik, M., "Relevance: An Analysis Illustrated on Science Education in the Third World", *Interciencia*, X (January–February 1985), pp. 9–14.

14.4, and in 1980 16.7 per teacher. In Latin American mass universities, teachers are still usually appointed "on part time". If figures on the absolute number of persons who do some teaching are converted into "full-time equivalents", in 1980 there were 27.7 students per "equivalent full-time teacher".[40] In most Latin American universities, there is no tradition of direct or informal contact between students and teachers. In Argentina, although the proportion of part-time university teaching posts—*dedicacion convencional*—has decreased from 77 to 73 per cent of the total number of teachers, this is not a great improvement. Conditions in the private universities are no better.

In addition to those persons classified as "teachers" who provide only 41 per cent of all teaching in Argentinian universities, there are "auxiliary teachers". These exist in a ratio of 1:1.4; the number of the latter is larger if we include unpaid auxiliary teachers. These unpaid—*ad honorem* as they are called locally—academics form a substantial group in modern Argentinian universities, but there are no exact statistics on them. The paid and the unpaid assistants are individuals who ought still to be in training. The fact is that almost 70 per cent of the directors of "practical work"—*jefes de trabajos prácticos*—and 86 per cent of the teaching assistants—*ayudantes de docencia*—are employed by the universities for a few hours a week. These arrangements probably interfere with their scientific education and there are serious doubts about the quality of their work as teachers.[41]

There are, however, Latin American countries in which conditions in higher education are better, since some attention is given to improving capacities for research and teaching in the universities. Thus, in Venezuela, 61.44 per cent of the total number of teachers are in full-time appointments—*dedicación exclusiva or tiempo completo*—and fewer than a third work on appointments of *dedicación convencional*. But there too scientific productivity is poor and confined to a few institutions.[42]

Despite these scattered efforts, at the beginning of the 1970s, there was no significant change in the proportion of graduates of special programmes in technology in comparison with the total number of university graduates. The physical sciences have always been feebly represented in the total student bodies in Latin American countries. In 1970, only 5 per cent of university graduates had studied the physical sciences.[43] Engineers made up 14 per cent of the student bodies; 17 per cent were in the medical sciences and 4 per cent in the agricultural sciences. Up to 1978, there was

[40] Sagasti, F., "El Desarrollo Científico y Tecnológico del Perú: Situación Actual y Lineamientos de Política". Paper presented at the Annual Conference of Executives, Arequipa Instituto Peruano de Administración de Empresas, 1982.

[41] FLACSO-Programa Buenos Aires, *op. cit.*, pp. 67–70.

[42] Oficina de Planificación del Sector Universitario, *La Educación en Venezuela* (Caracas: CRESALC–UNESCO, 1984), p. 45.

[43] Vivas, J., "Formación Universitaria en Ciencias e Ingeniería y el Sistema Científico-Tecnológico en América Latina", in *Universidad y Desarrollo en America Latina y el Caribe*, *op. cit.*

little change in the distribution. There was even a slight decrease in the percentage of graduates in the physical and engineering sciences in the total of graduates. Students in the physical sciences had dropped to 3 per cent, engineers were stationary at 14 per cent, the medical sciences had declined to 14 per cent and the agricultural sciences remained at 4 per cent of the total enrolment.[44] One of the explicit aims of the last military regime in Argentina was to reorient enrolment towards disciplines and programmes of "national interest". The effect of this effort of "reorientation" was almost nil. The military did, however, bring about a decline in the numbers of all branches of study, especially in sociology and psychology, to which the military regime had been particularly hostile.[45]

Of the total of graduates who enter the learned professions, the percentage engaged in research and development is very small and highly heterogeneous. Argentina, Brazil and Mexico have more than 8,000 research workers each, Brazil having 24,000. The middle-sized countries in the Andean sub-region have an average of between 1,500 and 4,000 research workers; the small countries of Central America and the Caribbean have between 400 and 800 per country. Only five countries in Latin America have more than 30 research workers per 100,000 inhabitants; these are Argentina, Chile, Uruguay, Cuba and Trinidad–Tobago. The comparable figures in the same period for Canada are 72, the United States 247, France 126, Israel 643, Switzerland 247, the Soviet Union 482.[46]

The number of unemployed scientific and engineering graduates in Latin America appears to be on the increase. In Venezuela, it is estimated that a quarter of all engineers are unemployed. In Brazil, at the beginning of the 1980s, 600,000 of the two million unemployed recorded by the Ministry of Labour were persons with undergraduate degrees or with some work in a postgraduate programme. This figure does not include underemployed science and engineering graduates or those who are employed outside the field in which they were trained.[47]

The Financial Support of Higher Education and Research

In the last 15 years, there has been a substantial increase in the financial resources made available for scientific and technological research in Latin America, but the appropriations remain well below the recommendations of at least 1 per cent of the gross national product put forward over many years by international organisations. Latin America is in the last position in the world with only 0.31 per cent of gross national product spent on research and development, behind Africa which spends 0.47 per cent of its gross national

[44] UNESCO, *Evolution quantitative et projections des effectifs des systems d'education d'Amerique Latine et des Caraibes: Analyse statistique* (Paris: UNESCO/MINEDLAC/Pre/6, 1979).

[45] FLACSO-Programa Buenos Aires, *op. cit.*, pp. 55–62.

[46] Sagasti, F., Chaparro, F., Paredes, F. and Jaramillo, H., *op. cit.*, p. 36.

[47] Reis, J., "Desemprego", *Ciencia e Cultura*, XXXIV (February 1982), pp. 2–3.

product. Expenditures of 0.5 per cent by Venezuela or 0.6 per cent by Mexico of the gross national product on scientific and technological research, given the other handicaps, do not offer much prospect of competition with countries which spend 2.5 or 3 per cent of a much larger gross national product.

In 1975, the highest levels for research and development expenditure in Latin America were reached in Brazil, Cuba and Venezuela. These countries spent US$10, 11.5 and 15.8 per capita respectively; the countries of Western Europe and North America spent an average of US$78 per capita.[48]

Those countries, especially Brazil, and to some extent Mexico and Venezuela, in which the governments have expressed the intention of developing research so that it could contribute to programmes of development, have had higher rates of expenditure. At the end of the 1970s, these three countries accounted for 75 per cent of the expenditure of all of Latin America on research, although their total populations came to only 57 per cent of the total of all the countries.

Research conducted directly under the auspices of government receives the largest amount of financial support, although the largest concentration of research workers is in universities (Table II).[49]

Most universities allocate their funds in accordance with traditional institutional criteria; they are distributed among the different academic departments, faculties and institutes; these units then spend what is appropriated for them as they desire. The universities do not draw up their budgets with research as a principal concern. "Most of the resources which the universities in fact allocate to research are fixed (salaries, purchases, etc.). An additional investment, which almost never exceeds 10 per cent of the total, is necessary for specific research activities."[50] It has been proposed that a centralised body be established to allocate in each university this additional amount, with the intention of supporting particular research projects which are thought on intellectual or practical grounds to be of especial importance.

A common feature of academic life in Latin America is the grave insufficiency of provision for university teaching and research: teachers and auxiliary staff are ill paid; equipment and materials for laboratories are lacking; the supply of scientific literature in libraries is not kept up to date; teaching material and sometimes class-room or laboratory space are inadequate.

[48] Sagasti, F., Chaparro, F., Paredes, F. and Jaramillo, H., *op. cit.*

[49] It is very difficult to extract from the available information the percentage of these expenditures really applied to research; e.g., in the Latin American universities, "the fact that there does not exist in the budget structure of most . . . universities a simple and direct form of arriving at the amount of resources allocated to scientific and technological activities, clearly indicates that this information has not been given importance when making decisions in these matters . . .". Centro de Desarrollo Interuniversitario de Desarrollo Andino, *Problemas y Perspectivas del Financiamiento de la Investigación en Algunas Universidades de la Región Andina* (Paris: UNESCO, SC-81/Conf.202/Ref.5, June 1981).

[50] *Ibid.*

TABLE II

Distribution of Expenditures on Research by Sector of Activity in Selected Latin American Countries, in Thousands of Units of National Currency and US Dollars

Sector of activity	Brazil (1978) Cruzeiros	US $	per cent	Mexico (1978) Pesos	US $	per cent	Chile (1978) Pesos	US$	per cent
1. Universities	5,548,000.0	307,028.2	26.7	1,541,576.4	67,851.1	24.7	423,271.4	11,364.2	17.3
2. Public Sector[a]									
a) Governmental agencies	8,791,000.0	486,496.9	42.3	3,775,926.0	166,193.9	60.5	n.d.	n.d.	n.d.
b) Public corporations	6,442,000.0	356,502.5	31.0	68,653.2	3,021.7	1.1	n.d.	n.d.	n.d.
Sub-total	15,233,000.0	842,999.4	73.3	3,844,579.2	169,215.6	61.6	1,525,565.2	40,959.2	62.4
3. Private Sector	n.d.	n.d.	n.d.	530,502.0	23,349.6	8.5	496,453.3	13,329.0	20.3
4. Others[b]	—	—	—	324,542.3	14,284.4	5.2	—	—	—
Total	20,781,000.0	1,150,027.6	100.0	6,241,200.0	274,700.7	100.0	2,445,289.9	65,652.4	100.0

Sector of activity	Colombia (1978) Pesos	US $	per cent	Ecuador (1979) Sucres	US $	per cent	Peru (1976) Soles	US $	per cent
1. Universities	215,034.3	5,500.2	26.7	41,127.1	1,645.1	14.1	348,000.0	6,059.5	12.6
2. Public Sector[a]									
a) Governmental agencies	482,417.8	12,339.4	59.9	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
b) Public corporations	3,221.5	82.4	0.4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Sub-total	485,639.3	12,421.8	60.3	1,186,463.9	7,458.5	64.2	2,275,000.0	39,613.5	82.3
3. Private Sector	104,698.4	2,678.0	13.0	63,072.3	2,552.9	21.7	140,000.0	2,437.7	5.1
4. Others[b]	—	—	—	—	—	—	—	—	—
Total	805,372.0	20,600.0	100.0	290,663.3	11,626.5	100.0	2,763,000.0	48,110.7	100.0

Sector of activity	Venezuela (1978) Bolivars	US $	per cent	Costa Rica (1981) Colons	US $	per cent
1. Universities	244,052.7	56,855.6	28.2	37,367.8	2,466.0	47.6
2. Public Sector[a]						
a) Governmental agencies	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
b) Public corporations	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Sub-total	621,382.3	144,760.0	71.8	33,632.5	2,219.6	42.8
3. Private Sector	n.d.	n.d.	n.d.	10,332.7	500.4	9.6
4. Others[b]	—	—	—	—	—	—
Total	865,435.0	201,615.6	—	81,333.0	5,186.0	100.0

a. For those in which there is not a breakdown of information available for the two categories of public research centres, only the total for the sector is given.
b. This refers mainly to the external sector, e.g. regional or international research centres within the country.

SOURCE: Sagasti, R., Chaparro, F., Paredes, F. and Jaramillo, H., *Un decenio en transición: Ciencia y Tecnologia en America Latina y el Caribe durante los Setenta* (Lima: GRADE, March 1983).

In Argentina, the reduction of governmental support for education in general had injurious consequences for research as well as teaching. In 1970–71, expenditure in education constituted almost 15 per cent of total government expenditures; it diminished in the two subsequent years and then increased to 16 per cent in 1974. The decline was resumed so that in 1976, 1977 and 1983 the lowest figures of the last 40 years were reached. In 1983, the Ministry of Education received 8 per cent of the national budget.[51]

In 1982 the largest national universities in Buenos Aires, La Plata and Cordoba, received 41 per cent of the Argentinian national university budget. The latter has grown very slowly; between 1976 and 1982, on average the annual increase has been 1.4 per cent. At the beginning of the 1980s, the military dictatorship, in order to increase the income of the universities, introduced tuition fees in the national universities; this produced no significant increment of income for the universities—only about 4 per cent of the total budget of the Universidad de la Plata and the Universidad de Mar del Plata in 1981 came from these fees. The measure was rescinded by the civilian government installed in 1983. The meagre income of the Argentinian universities barely suffices to carry existing teaching activities. Eighty to 90 per cent of the income of universities is applied to salaries. There is no margin to support innovations in teaching or research.

In Brazil, the central government and the governments of four federal states each have their own system of higher education and are responsible for the institutions in their charge. The state of São Paulo maintains two of the leading Brazilian universities: Universidade de São Paulo and Universidade de Campinas. Besides the budget for current expenditures, the government provides special resources for the construction of campuses, the modernisation of laboratories, the academic improvement of the teaching staff and the support of research. In 1983, 3,590 university teachers received support from the Conselho Nacional de Desenvolvimento Científico e Tecnológico in the form of fellowships for research.[52] This is a method of supplementing regular salaries, which vary according to the individual's academic qualifications. Fellowships are granted for the execution of research projects, the proposals for which are assessed by advisory panels of scientists.[53]

Venezuela is one of the Latin American countries which has attributed great importance to education. Between 1964 and 1983 the national educational budget grew about elevenfold, while expenditure on education increased eighteenfold.[54] Since 1974, with the rapid increase in national

[51] República Argentina, Ministerio de Educación y Justicia. Dirección General de Presupuesto. See also FLACSO-Programa Argentina, *op. cit.*, pp. 76–78.

[52] Conselho Nacional de Desenvolvimento Científico e Tecnológico, *Relatorio de Actividades* (Brasília: CNPq, 1983).

[53] Postes, H., *op. cit.*, pp. 22–24, 27–28.

[54] Oficina de Planificación del Sector Universitario, *La Educación Superior en Venezuela* (Caracas: CRESALC–UNESCO, 1984), pp. 50–54.

revenues following the rise in oil prices, educational expenditure has grown at a much greater rate than the national budget. In 1979, the share of the educational sector in the total national budget reached 20 per cent. In 1983, the share of the Ministry of Education was 17.8 per cent of the expenditures of the government. Higher education received a large part of the increased expenditure. It rose from 25.7 per cent of the budget of the Ministry of Education in 1964, to 30.4 per cent in 1971, to 45.9 per cent in 1980. This increase has been used for the "social protection" of the students, and for an increased number of teachers on full- and part-time appointment; the ratio of students to "full-time equivalent" teachers in the national universities decreased from 16.1 in the academic session of 1971–72 to 14.6 in 1980–81. It has also been used to create a substantial number of higher educational institutions and to open new research centres and postgraduate programmes.[55] The Venezuelan universities in 1970 employed 71 per cent of all the research workers in the country. The proportion had diminished only a little by 1977, falling to 69 per cent in that year.[56]

The relationship between the universities in which such a large percentage of the scientists of the country are concentrated, and the government's science and technology policies, are however not very close. So far, the main effect of the government's science and technology plans is probably to have deepened general awareness of the importance of science; they seem to have had little other effect.[57]

In Cuba, there has been a 6.8 per cent annual increase in the budget for higher education since 1959, and in 1984 the budget for higher education—at 195 million pesos—was more than two-and-a-half times higher than total educational expenditure in 1957–58 when it was 74.4 million pesos. Throughout the period, the rate or increase in funds exceeded that of enrolment. This increment has been used partly for scientific research and postgraduate studies, the improvement of the supply of space, equipment and materials, and for assistance to students. In the 1980s, a system of contracts was instituted by which firms pay the Centros de Educación Superior (CES)—of which there are 46 throughout the country—for the research results which are of interest to them. This permits each research institution to obtain additional funds for carrying out its own research.[58]

Disillusionment with the Universities

In Latin America, a certain degree of disillusionment has set in about the expenditures on education. The social equity of the system of financing

[55] *Ibid.*

[56] Consejo Nacional de Investigaciones Científicas y Tecnológicas, *Ciencia y Tecnologia en Cifras* (Caracas: CONICIT, July 1981), pp. 14–15.

[57] Antonorsi, M. and Avalos, I., *La Planificación Ilusoria* (Caracas: CENDES/Ateneo, 1980), p. 135.

[58] Departamento de Estudios para el Perfeccionamiento de la Educación Superior, Universidad de la Habana, *La Educación Superior en Cuba* (Caracas: CRESALC–UNESCO, 1985), pp. 36–39.

higher education has been questioned. It is often charged with resulting in a net transfer of income from the poor and the very rich to the upper middle classes.[59] The underemployment and unemployment of educated persons, the unresponsiveness of the market to educational qualifications, the concentration of students and of employment opportunities for educated persons on subjects and sectors that are not directly productive, are among the facts adduced by the critics of the notion that educational expenditures are an investment which brings returns to society and to the educated individual.[60]

These economic arguments have been added to the "technologistic" rhetoric with its emphasis on a narrow utilitarianism that grew throughout the 1970s. Together they made for criticism of the university. The latter was charged with inability to solve social and economic problems, or to meet the demands for a closer link with the economic system.

To understand the process which led to this situation, it is worthwhile referring briefly to the Brazilian experience. Since the middle of the 1960s, the Brazilian state has created and consolidated institutions for the support of research in science and technology; the policy has relied heavily on the universities, which enjoyed a notable growth in government funds for buildings, equipment and research until the end of the 1970s. Since then, a new direction in the allocation of resources has strengthened research and development centres, which were not linked with the universities: the state firms and governmental research institutes like Petrobrás, Eletrobrás, Nuclebrás and others, were the beneficiaries of the new policy. It is estimated that the participation of state firms in the total of government expenditures on science and technology reached about 32 per cent (14 billion cruzeiros) in 1979.[61] Among the causes of this change of orientation are the growth of technological concerns and demands in the state firms, the existence of human resources for research in sufficient quantity and quality—a measure of success of the universities—and a reluctance to allow the universities to choose their own problems for research.

The difficulty faced by different Latin American countries in meeting the interest payments on foreign loans has added to the pressure to reduce expenditures on education, and, together with other considerations, has made for a more critical attitude towards education. The state firm and not the university has been favoured by the ever more urgent demands to close the technological gap between the central and the peripheral countries.[62]

[59] Tedesco, J. C., *Trends and Prospects in the Development of Higher Education in Latin America and the Caribbean* (Paris: UNESCO, ED-83/WS/75, June 1983), pp. 21–22.

[60] Boeninger Kausel, E., "Políticas Alternativas de Financiamiento de la Educación Superior", in Banco Interamericano de Desarrollo, *El Problema del Financiamiento de la Educatión Superior en América Latina* (Washington, DC: BID, 1978).

[61] Dagnino, R., "A Pesquisa Cientifica e Tecnologica na Universidade Brasileira: Caracterizando a Crise". Paper presented at the international seminar on Science and Technology Policy in Latin America, Guanajuato, Mexico, UNAM–UAM-Universidad de Guanajuato, 2–6 November, 1982.

[62] Dagnino, R., *op. cit.*

From within the national academic communities, anxious voices have been raised, emphasising the importance of research in overcoming the crisis, and "the need to preserve the valuable scientific and technological potential built up at the cost of many sacrifices over many years, which is in danger of being lost overnight if government indifference and disorganisation as regards this matter continues".[63]

The economic crisis has resulted in a more circumspect analysis of the actual possibilities of scientific achievement under present conditions. A Brazilian academic scientist expressed his attitude nearly a decade ago in terms which are no less pertinent now:

> Contrary to what may be expected, the Brazilian university, as an institution, does not have the mechanisms, aptitude, or desire to discriminate or select, among its members, the most talented and productive ones. From this derives its tendency to distributive justice which leads it to promote, among departments and teachers, the equalisation rating of their budgets.[64]

He also charged that in no university has a significant argument been put forward for differences in remuneration on the basis of merit. On the contrary, he said, the trend is towards the extension to all teachers of the incentive originally instituted in the universities, to stimulate the desire to do research. The conclusion from these experiences is that expenditures in universities do not help to advance scientific research. If the latter is to be advanced, it must be through specially designed grants, made independently of university budgets.

Further arguments for this procedure include the view that it would permit greater selectiveness in the choice of research projects through the support of particular projects. It is also said that it would promote a reorientation of research towards projects of national interest, and, by drawing on the judgement of leading scientists, foster an improvement in the quality of the projects. Against these arguments, critics have said that it would lead to the development of excessive dependence on these external bodies which often fluctuate in their interests and goals; it would also discharge the universities from their responsibility to provide resources for research and from attempting to include research as one of their objectives. At present, the universities do not even provide the most elementary counterpart to external support for research.[65]

Funds supplied by the national science councils of the various countries grew less rapidly towards the end of the 1970s and beginning of the 1980s, in several cases receding to the levels of 1975. University research has had to rely on international support. For example, in the case of Colombia, the contributions from agencies other than government are still about 50 per

[63] Motoyama, S., "Historia da Cienca, Cienca e Tecnología e a Historia da Dependencia do Brasil", *RBT: Revista Brasileira de Tecnología*, XIV (May–June, 1984), pp. 5–17.

[64] Brener, Z., "A Instituicao e os Orgaos Financiadores", *Administracao da Atividade Cientifica* vol. 5 da Colecao Estudos de Politica Cientifica e tecnologica (Brasilia: CNPq, 1981), pp. 35–38.

[65] *Ibid.*

cent of the total expenditure of the Fondo Colombiano para la Investigación Científica (COLCIENCIAS). The main direct source of funds for research other than the national budget has been international technical co-operation; the most important external sources are the United Nations Development Programme, UNESCO, the Organization of American States, and the International Development Research Centre of Canada.[66]

In Panama, where research is only just beginning, in 1983–84, the Vicerrectorado de Investigación y Postgrado of the Universidad de Panamá obtained approximately one-and-a-half million balboas to support research from international agencies, including the Organisation of American States, UNESCO, Panamerican Health Organisation/World Health Organisation and the American Agency for International Development. This has permitted 53 research projects to be approved for support.[67]

In Latin America today, the funds of government departments are often used to support research on topics judged economically and socially important. At the same time, the national science councils are to some extent abandoning traditional policies which respected the autonomy of scientific research.

Research and the "Brain Drain"

Although Latin America has had a certain degree of success in the training of research workers, it has not succeeded in employing them properly. A result of this is the "brain drain". It has not ceased; it has even grown in some of the scientifically most advanced countries in the region. The brain drain is partly attributable to the lack of satisfactory appointments for persons with qualifications good enough to obtain appointments outside Latin America. Some arises from political persecution. The exodus of scientists is important, except in Brazil and Venezuela, and recently in Mexico, which since 1978 has had an increased number of resident foreign scientists; this has probably exceeded the number of Mexican scientists who have emigrated. However, even in Venezuela and Mexico, the current economic crisis threatens the survival of fledgling national scientific communities. The Mexican government has responded to the dangers of the loss of its scientists by establishing, in July 1984, the Sistema Nacional de Investigadores, with a programme of research scholarships at three levels of seniority. The scholarship is a supplement to the salary, equivalent to two, three or five times the minimal monthly salaries of the Federal District, according to the degree of seniority of the scholarship-holder.[68] In Venezuela, alarm is

[66] Instituto Colombiano para el Fomento de la Educación Superior (ICFES), *Primer Encuentro de Coordinadores de Investigacion Universitaria. Memorias*, Serie Memorias de Eventos Cientificos Colombianos (Pamplona: ICFES–COLCIENCIAS-Universidad de Pamplona, November 1982).

[67] Dirección de Planificación Universitaria de la Universidad de Panamá, *La Educación Superior en Panamá* (Caracas: CRESALC–UNESCO, 1985).

[68] See Roche, M., "El Ejemplo de México", *Interciencia*, X (July–August 1985), p. 170.

increasingly expressed by spokesmen for the scientific community. At the end of 1984, the emigrants included one of the two experts in the country in the viral pathology of plants, one of the very few specialists on fermentation in the growth of bacteria used as a source of proteins in animal feeding, three of the 18 research scientists in electronics, and two of the six specialists in magnetic resonance. Their destination was in all cases a central country, usually the United States. In addition to these persons who already had very respectable achievements to their credit, young research workers who have completed their postgraduate training and who have not yet made a mark are beginning to leave because they cannot find employment in Venezuela.[69]

It is estimated that in Bolivia, since 1978, there has been an internal brain drain in which 60 per cent of Bolivian scientists have entered activities which have nothing to do with research. In Chile, the exodus reached 65 per cent of all workers in the field of theoretical physics between 1963 and 1978. In Peru, between 10 and 20 per cent of scientists left the country between 1968 and 1978; towards the end of the 1970s more than half the Peruvian mathematicians holding doctorates were working abroad.[70]

In nine Latin American countries in 1972, 5.7 per cent of the total number of physicians had settled abroad, 92 per cent of these in the United States.[71] In countries like Guyana, in 1978 emigration had risen to 80 per cent in medicine and engineering—60 per cent in the case of technicians.

The reasons usually given for this exodus are economic: the search for better professional opportunities, particularly for physicians and scientists. Political difficulties have prompted the emigration of Argentinan, Chilean and Uruguayan scientists. The lack of a suitable atmosphere for research is a common complaint among basic scientists who have emigrated or who have considered emigrating.[72] They cite the lack of continuity in support, the outdatedness of libraries and lack of efficient documentation services, the bureaucratic morass of the universities, the absence of opportunities for appointments to match their professional qualifications, and the lack of auxiliary staff, both technical and administrative.

A few instances illustrate the common situation.[73] Jorge Ferrer is an

[69] Layrisse, M., "Recursos Humanos para Ciencia y Tecnología", *El Nacional* (Caracas), 26 March, 1985.

[70] Sahade, J., "Diagnóstico de la Situación del Investigador Científico en América Latina y el Caribe", Annex V of the Latin American Consultation about the Situation of Scientific Research Workers (Montevideo: UNESCO's Regional Office of Science and Technology for Latin America and the Caribbean, SC-81/Conf.202/Ref/7, 15 June, 1981), p. 6.

[71] UNESCO, *El Exodo de Profesionales con Estudios Superiores en los Estados Partes en el Convenio Regional de Convalidación de Estudios, Titulos y Diplomas de Educación Superior en América Latina y el Caribe*, Estudios y Documentos de Educación No. 45 (Paris: UNESCO, 1983).

[72] Vessuri, H., "Scientific Immigrants in Venezuela: National Identity and International Science", in Marks, A. and Vessuri, H. (eds), *White Collar Immigrants in the Americas and the Caribbean* (Leiden: Department of Caribbean Studies, Royal Institute of Linguistics and Anthropology, 1983), pp. 171–198.

[73] Interviews for *El Periodista de Buenos Aires*, X (17–23 November, 1984), pp. 43–45.

Argentinian scientist who graduated from the Universidad de Buenos Aires in 1957, and who is today a virologist at the University of Pennsylvania and an international figure in cancer research. He began to do research on leukaemia at the Instituto de Investigaciones Hematológicas of the Academia Argentina de Medicina, In 1964, he received a scholarship to serve as research associate at the Roswell Park Memorial Institute in Buffalo, New York, where he remained until 1966. That year he received the Eleanor Roosevelt scholarship of the International League for Cancer Research. This allowed him to spend three years at Stanford University where he worked on experimental leukaemia with Professor Henry Kaplan. In 1968, he went back to Argentina in order to explore the possibilities of an appointment there, but did not find a warm welcome. In 1969, he decided to stay in the United States and accepted the direction of the section on viral oncology in the veterinary faculty at the University of Pennsylvania. This was an exceptional opportunity, because it gave him the chance to study mechanisms of leukemogenesis in cattle. At the University of Wisconsin, evidence had been produced suggesting the existence of the virus; Ferrer's research confirmed its existence and characterised it, developing the necessary techniques to detect it in a routine fashion in cells, tissue cultures and biological liquids. With this technique, it became possible to study in great detail the biology of the viral infection and its natural history. Cattle leukaemia not only had intrinsic interest and enormous economic significance, but was also highly relevant to the understanding of human leukaemia. Despite the importance of cattle in Argentina, no comparable research has been done there.

Another Argentine scientist, Dr Roberto Poljak—originally a geologist, later a physician and finally a molecular biologist—is now a well-known immunologist and crystallographer. He received his doctorate in natural sciences from the Universidad de La Plata in 1956, with a thesis on the crystallography of minerals subjected to high temperatures. In 1958 he received a scholarship from the United States National Academy of Sciences to work at the Massachusetts Institute of Technology. He became interested in biological problems and, in 1959, moved to the laboratory of Professor Alexander Rich, of the biology department at the same institution. There he attended a seminar in which Dr John Kendrew revealed to the participants the atomic structure of mioglobin, the protein which provides oxygen in muscles.

From that time on, Dr Poljak became interested in macromolecules. He decided to study a protein with catalytic function, an enzyme, and chose the lisozyme. One year later he went to England, with his work on lisozyme well under way. At the Royal Institution, Sir Lawrence Bragg became enthusiastic at the idea of solving the tridimensional structure of an enzyme, because it would allow a rigorous understanding of the chemistry and thermodynamics of biological catalysis. Dr Poljak published the first tridimentional model of lisozyme at low resolution in 1962, but then

abandoned the project because he was still inexperienced and was discouraged by the rumour that other groups led by scientists of the eminence of Dr Linus Pauling were also working on lisozyme. He decided to change his subject and accepted a position at the department of biophysics in the medical school of the Johns Hopkins University. There he completed his biological education, and worked intensively on the chemistry of proteins and genetics of bacteriophages. He became increasingly interested in immunology, and in 1964 began work on a crystallisable fraction of the antibody molecule, obtaining interesting results in 1968. From then on his project acquired momentum. Two other Argentinian crystallographers joined him in his laboratory, Drs Mario Amzel and Leo Becka, who, before leaving Latin America altogether, had worked in Venezuela since August 1966, in the aftermath of the military intrusion into the faculty of sciences at the Universidad de Buenos Aires.[74] In 1970, the map of low resolution was obtained, and in 1972 Dr Poljak analysed the structure of immunoglobulin with atomic resolution. Since 1981 he has lived in France, where he is director of the department of immunology and head of the unit on structural immunology at the Institut Pasteur. He is also director of research in the Conseil national de la recherche scientifique. There are seven other Argentinian research directors at the Conseil. During all this time, macromolecular crystallography has been practically non-existent in Argentina. On a recent visit, Dr Poljak observed that there are several excellent physicists at the Universidad de La Plata, but they are isolated.

It cannot be said that Latin American governments are utterly indifferent to these losses. Intermittent but insufficient attempts are made to overcome them, as in the case of the Argentinian institution of the *carrera del investigador*. The Brazilian Operaçao de Retorno, founded in 1967 and administered by the Ministry of Foreign Relations, has aimed to bring back Brazilian scientists who have been working abroad. The Colombian government began in 1972 the Programa de Retorno de Profesionales y Técnicos, with the support of the United Nations and the International Labour Organisation.[75]

Establishing Effective Connections between Academic Research and Industry

In the 1950s and 1960s, much effort was made in Latin America to find an institutional structure which would be propitious to the formation and effectiveness of a body of active scientists. One of the aims of this striving was to foster economic development in the region. This led to the

[74] Vessuri, H., "Scientific Immigrants in Venezuela", *op. cit.*

[75] COLCIENCIAS–CENALDE, *Evaluación del Programa de Retorno de Profesionales y Técnicos*, Serie Migraciones Laborales No. 13 (Bogotá: Ministerio del Trabajo y Seguridad Social/Organización Internacional del Trabajo, 1978).

establishment of faculties of science in many universities, research institutes and national scientific and technological research councils. Training for technology was not given a prominent position, despite the fact that it was given as much prominence as science in the various programmatic declarations of the time.[76] This disregard for technology can perhaps be explained by the fact that the main intention of the leaders of the incipient national scientific communities was the implantation of scientific activity. These leaders were in a position to influence politicians and high civil servants because science could be seen as adding to the cultural prestige of countries, without interfering with existing economic arrangements. Technology, however, was quite another thing, since it touched more intimately on problems of economic development about which there was much contention.

The inattention to technology as distinct from science was also in part a consequence of the then dominant "scientistic" outlook, which simplified the relations between science and technology through the use of the "lineal model". According to this model, technological innovation is always a consequence of scientific discovery, through a process which begins with the knowledge produced by basic research, and it ends in the market studies that lead to the economic use of this knowledge, after having passed through various stages of applied research, experimental development, engineering, etc. Thus, it was presumed that once the capacity for producing scientific knowledge was set in motion, the latter would flow in a continuous fashion and be incorporated without difficulty into the economy which, it was assumed, was awaiting it eagerly.[77] Only in the last decade has this scheme come under criticism.

A more critical attitude was stimulated by a number of reports. These included the Technology Transfer Pilot Project of the Organisation of American States, begun in 1972, the Scientific and Technological Policy Instruments Project of the International Development Research Centre of Canada, begun in 1973 under the co-ordination of Francisco Sagasti, and the report of the Interamerican Development Bank and the United Nations' Economic Commission for Latin America, begun in the second half of the decade and directed by Jorge Katz.[78] Some of these reports presented more realistic analyses of the relationship between science and technology, the

[76] Sabato, J. and Mackenzie, M., *La Producción de Tecnología. Autónoma o Transnacional* (Mexico: ILET/Nueva Imagen, 1982).

[77] Rosenberg, N., "How Exogenous is Science?" in Rosenberg, N. (ed.), *Inside the Black Box: Technology and Economics* (Cambridge: Cambridge University Press, 1982), pp. 141–162.

[78] A substantial number of monographs and papers were produced in connection with these projects. See in particular Sagasti, F., *Ciencia y Tecnología para el Desarrollo: Informe Comparativo Central del Proyecto sobre Instrumentos de Política Científica y Technológica* (Ottawa: International Development Research Centre, IDRC-109s, 1978); Katz, J., *Cambio Tecnológico en la Industria Metalmecánica Latinoamericana* (Buenos Aires: CEPAL/BID/IDRC/UNDP, 1982).

differences between applied science and technology, the obstacles hindering the articulation of economic institutions and scientific and technological research institutions, the supply and demand for technology, and the relations between technology and foreign investigation.

In most of the countries in the region, the universities possess both the staffs and the institutional arrangements which could, in principle, contribute to technological innovation. But there has also been a strong obstacle arising from the tradition of the universities, and even of the small scientific elites of the various Latin American countries. Academics have not liked the idea of doing academic research for commercial purposes; they have had little understanding of industry and little contact with it. The attitudes of the business men who have to decide on whether to use the innovations offered by academic research have also played a part in obstructing the movement of scientific knowledge into economically profitable technology.

Nevertheless, there are already in the region different types of institutional experiments in the organisation of relationships between university and industry. The recent experience of the Universidad Autónoma de México in the creation of the Dirección General de Desarrollo Tecnológico in 1983, includes the formulation of research projects and other activities of interest to academic science teachers. This new institution has undertaken to provide specialised technological information, information about industrial property including patents, licences and brands, advice on the management of technological research projects, direct contacts with firms, the writing, negotiation and performance of contracts, technical consultancy and financial management.[79] The Fundación UCV of the Universidad Central de Venezuela proposes a different scheme for the creation of commercial firms owned by the different institutes or laboratories of the university, to exploit inventions or services produced by scientists on the university staff, as a source of independent revenue for the university and for the continuity of research.[80]

The performance within the university of research which can be profitable for industry is hampered by the organisation of university teaching and research; these are often very specialised within disciplinary and subdisciplinary fields in which individual and small-group research has little contact with research workers in other fields. Technological research projects usually require the contributions of several disciplines and specialities, and hence the participation of different departments within the university. There are at present no institutional arrangements to foster such communication among the different groups in most universities. There is

[79] Cadena, G., "La gestión de proyectos tecnológicos de la Universidad Autónoma de México", México, UNAM, 1984 (mimeograph).

[80] Fundación U.C.V., *Estatutos* (Caracas: Fundacion Universidad Central de Venezuela, 1983).

also distrust among academic scientists of becoming involved in large projects which they themselves do not fully control.

In a few Latin American industries, such as the advanced electronics industry, there have been close connections between industrial firms and academic units. This is partly a consequence of the advanced academic training received by engineers and scientists, who are active in production and willing to turn to the university for advisory or other services with specific objectives defined by themselves on behalf of the firm.[81] But even if industry is in principle receptive to the knowledge which academics could offer, industrialists tend to be distrustful of the universities and academic scientists.

Future Prospects

The main obstacles to the consolidation of scientific research in the university are the poor traditions of research within the universities, the frictions between the institutional needs of scientific research and the organisation of the university, frictions between research and teaching, and between scientists and politicians.

Some of these obstacles were discussed in a debate in 1983 in *Interciencia* on the question "Should university research be abolished in Latin America?", an issue which had been posed previously.[82] On this occasion, the debate reopened with an interview of Dr Marcel Roche with Dr Ernesto Mayz Vallenilla, former rector and founder of the Simón Bolívar University in Venezuela.[83]

Dr Mayz's main point was that, in view of the problems of mass universities, the proliferation of universities and university institutes basically devoted to training for the professions, and the consequent failure to attain a reasonable level of quality, it had become necessary to create two kinds of institutions: one for higher education and another for science and technology. The former would provide teaching for "training for the professions"; the other would concentrate research activity in special research institutions and in industrial establishments which do research.

Dr Mayz's proposal was intended to "avoid the confusion and cant produced by the hotchpotch of teaching and research",[84] by separating the two systems, although he recognised that they were closely linked. This

[81] Pirela, A., "La Ingeniería Eléctrica y Electrónica: Disciplinas en la Trayectoria del Cambio Tecnológico", in Vessuri, H. (ed.), *Ciencia Académica en la Venezuela Moderna, op. cit.*, pp. 135–172; Pacheco, C. A. and Tapia, J. R. B., *Informática e Reserva do Mercado* (Campinas: Cadernos de Discussao 2, 1984).

[82] See, e.g., Sagasti, F., "La Universidad y el Desarrollo de la Ciencia y la Tecnología", in Sagasti, F. (ed.), *Ciencia, Tecnología y Desarrollo Latinoamericano* (Mexico: El Trimestre Económico/Fondo de Cultura Económica, 1981), pp. 195–208; Schwartzman, S., *Ciencia, Universidade e Ideologia, op. cit.*

[83] Roche, M., interview with Mayz Vallenilla, E., "Abolir la Investigación en la Universidad?", *Interciencia*, VIII (March–April, 1983), pp. 82–92.

[84] *Ibid.*

connection would be effected through contracts between individual research workers and the universities, in order to provide teaching at the levels of master's and doctoral programmes. At the undergraduate level, in his scheme, research by teachers and training in research were unnecessary, because the aim of teaching was "to train professionals". As an exception, some first degree courses could have the co-operation of teachers-cum-scientists to train small groups of students who would receive an education with non-professional objectives. This would permit the selection, orientation and training of future research workers.[85]

Dr Mayz's proposal drew a response from Dr Francisco De Venanzi, founder of the Venezuelan Association for the Advancement of Science and rector of the Universidad Central de Venezuela during the first modern democratic government in 1958. He pointed out that many of Dr Mayz's proposed reforms could be carried out within the existing universities, and he firmly rejected the idea of the "two systems" suggested by Dr Mayz, because it would entail the loss of university autonomy. Dr De Venanzi pointed out that the separation of teaching and research had been tried in Sweden with rather poor results. He wished to keep them integrated, despite the fact that the mass universities had caused a concentration on teaching and the renunciation of scientific inquiry in many faculties. Such a tendency had to be reversed, in Dr De Venanzi's opinion, and it could be reversed if persons able in both teaching and research were appointed to university posts. He said:

> Research incorporated into teaching can undoubtedly awaken the scientific vocation, which is important and necessary in the education of research scientists, but its general function is even broader, since it is an essential instrument in active education, favouring the development of critical thought and introducing scientific methods, all of which are of great importance for the professions.[86]

The debate continued in subsequent issues of *Interciencia*. Dr Sagasti asserted that the university should carry out research only in connection with postgraduate teaching, and that other kinds of research connected with industrial and governmental needs and "pure knowledge" should be done by other institutions. But, in general, participants in the discussion rejected the idea of the abolition of the university by the removal of research from institutions of higher learning. It was generally agreed by other participants that both teaching and research should be maintained within the university.[87] The arguments for the retention of the dual function of the university did not deny that universities had to undergo substantial organisational and functional modifications.

[85] *Ibid.* See also Mayz Vallenilla, E., *El Ocaso de las Universidades* (Caracas: Monte Avila, 1984).

[86] De Venanzi, F., "Respuesta al Dr Mayz Vallenilla", *Interciencia*, VIII (March–April 1983), pp. 93–96.

[87] *Interciencia*, VIII (July–August 1983), pp. 236–242; *ibid.*, VIII (September–October 1983), pp. 303–307.

In the world as it is today, the elements necessary for creating, distributing and making productive use of crucial scientific and technological knowledge, are highly concentrated in a relatively few public and private research centres, located predominantly in the main industrial countries. These institutions are largely responsible for the development of new technology, particularly in electronics, biotechnology, materials and alternative sources of energy. The revolution in information systems which originated at the centres in North America, Western Europe and Japan threatens to increase the gap in knowledge between the "first" and the "third" worlds. The "Third World" is falling behind in basic engineering, especially in process- and equipment-design engineering. Given this situation, the Latin American countries must rethink their arrangements for their universities and research institutions.

A reconstitution of national research policies and of professional training, in order to orient them more to national objectives and resources, might mean giving up aspects of the ideal of the "cosmopolitan" scientist which has prevailed in institutions of higher learning throughout Latin America. It is not as though this ideal has been achieved in Latin America to any notable extent, but it has been the motivating ideal of reformers and of the few eminent scientists who have worked in the region. The question may be raised whether the attempt in Latin America to conform with this ideal is harmonious or in conflict with the application of scientific and technological knowledge to the practical problems of raising the standard of living of the ordinary people in these countries.

Is not Latin America wasting its resources in attempting to conform with the standards of achievement of scientific work at its highest levels? Would it not be better if scientists in Latin America turned their backs on science as a universally valied body of knowledge, ceased to strive to contribute to it, and ceased to judge themselves by its standards? Would it not be better if scientists in Latin America concerned themselves with finding solutions to practical technological problems? Would it not be better if the Latin American universities attempted to train their students for strictly practical tasks, rather than to make their best students into productive members of the world scientific community?

But the future is contained in the present. The existing universities in Latin America, with all their limitations, constitute the most important regional reservoir of scientific and technical knowledge, creative spirit, critical consciousness and intellectual energy. The mass university has a prejudicial relationship with scientific endeavour, yet it is a complex phenomenon which cannot be easily dismantled, being part and parcel of the backwardness of the region and its striving for improvement. If any solutions to the problems of practical progress or the growth of scientific knowledge are to be found, they will have to be found in a setting in which the mass university exists. The best hope is that it will be possible to form a small number of highly qualified scientists with genuine zeal to do research at a

high standard in special postgraduate training centres—with perhaps some special courses for carefully selected undergraduates within a few universities. Such a scheme should provide for a modest number of research institutes of outstanding accomplishment, a few of which would be devoted to fundamental science and most of the others to applied science.

Academic research has to be granted a privileged social space for the unobtrusive study of basic scientific and engineering problems, up to the best standards available. The results of this research might eventually be applied to national or local problems. The experience of recent decades in the industrial countries demonstrates that the value of academic research lies in the ability of scientists to undertake fundamental studies, which are not restricted by their immediate applicability to a given situation or context. By keeping this independence, academic research scientists have been able to produce the new ideas which turn out to be the life-blood of scientific and technological innovation. If they devote too much of their time and expertise to tackling immediate and specific problems, sooner or later they exhaust their intellectual capital and produce results which cannot stand up economically to international competition.

There are undoubtedly many fields of scientific work which it would not be advisable to develop intensively in Latin America. In those fields, technology will continue to be imported. But in the particular areas in which Latin America wishes to be competitive, concentrated efforts in science and technology have to be made. Then, if it is successful, the range of activities can be extended.

For these reasons, it will be necessary to strengthen existing research institutions, and to multiply those connections with research and development outside the universities. This does not mean reducing the importance of the universities but, on the contrary, seeking new forms of exchange of knowledge and stimulus. The university has an irreplaceable role in training future generations of research workers and in providing a better education to undergraduate students, as well as in strengthening the national capacity for scientific and technological research. It will undoubtedly not succeed with most of its students; it must try to succeed with some of them.

The universities, and the bodies which support research too, must recognise the costs of maintaining scientific activity. Once the choice of a fruitful line of research has been made, it must be supported with all the seriousness that the endeavour deserves. This entails both a scale of support for research in science and technology much larger than the current sums, and a much more effective means of allocating it. Political demands tend to be contradictory and short-sighted. Politicians frequently demand that scientific research contribute to the alleviation of the social and economic problems of their country, while at the same time they carry out policies which, intentionally or unintentionally, hamstring the intellectual activity of the university and render it incapable of meeting those demands.

At times of crisis, immediate solutions, usually imposed by external situations, tend to be preferred. Paradoxically, the immediate and hurried attempts which are intended to solve specific problems, often fail in practice. The true possibilities of academic research—both basic and applied—should be appreciated, because what seems the longest road may in the end be the shortest—one of attaining the desired goal of a science truly capable of fulfilling the promise of social usefulness.