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SCIENCE AND HIGHER EDUCATION IN BRAZIL: AN HISTORICAL VIEW*

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de Rio de Janeiro

From almost all points of view, the recent developments in the fields of science, technology and higher education in Brazil have been impressive. University enrollment grew from 212,000 in 1968 to an estimated figure of more than 1.1 million in 1977; the number of places offered in the Brazilian universities for incoming students went from 88,000 to about half a million in the same period.[1] Before 1965, only the University of São Paulo and a few other places offered some kind of graduate training, and only for a small number of students; in 1975, however, there were 673 graduate programs listed in all fields of knowledge, of which 183 provided doctoral degrees.[2]

Since the first basic plan for science and technology for the 1973-1974 period was published, the amount of resources allocated for scientific and technological development has been increasing steadily. The 1975-1977 plan projected total expenditures of almost one billion dollars per year in that field.[3] This total includes only a small fraction of the ambitious atomic energy program Brazil signed with West Germany in 1975, which is supposed to cost about 10 billion dollars in fifteen years.[4] The number of graduate students trained abroad on government fellowships has increased to some two thousand annually; these students usually leave the country with a commitment to return to a university or research institution, which they typically do.[5] The scientific community has unprecedented prestige and visibility: the annual meeting of the Brazilian Association for the Advancement of Science (SBPC) is now one of the most important cultural, intellectual and political events of the country's calendar.

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*The main sources for this article are the materials gathered by the research project on the social history of Brazilian science, coordinated by the author at the Research and Study Group of FINEP--Financiadora de Estudos e Projetos--in Rio de Janeiro. They consist of extensive bibliographic materials, documentation and in-depth interviews with about fifty leading Brazilian scientists in physical and biological sciences. A partial result of this study is forthcoming in As Ciencias Naturais no Brasil: Panorama Historico (Das Origens a Segunda Guerra Mundial), 1978.

What does this expansion of Brazilian science mean? What are the goals being pursued, and what are their chances of success? What are the forces and motivations behind this expansion?

There are obviously no easy answers to these questions, but several possible approaches. One could look at the official statements and budgets to identify explicit priorities;[6] one could try to relate these developments to specific demands, or lack of demands, in the economic sector;[7] or one could delve into the political and ideological motivations that supposedly lay behind decisions bearing on questions of science and technology.[8]

The strategy adopted here is historical; it tries to see how the present realities came to be. The assumption here is that a general comprehension of a country's economic and political history is essential to understanding its patterns of scientific and technological growth. Science, as a concrete activity of specific social groups, cannot, however, be inferred from global economic and political processes, but needs to be examined in relation to the developmnet of the learned professions, to cultural and religious movements and institutions, all of which must be dealt with on their own terms. Technology, in the sense of knowledge applied for practical purposes, is much more closely related to economic variables. Its relations with science are complex, often contradictory, and should not be taken for granted. This article emphasizes science, rather than technology, and is mostly concerned with the links between science, higher education, and culture, rather than the links between technology and economic conditions--a more fashionable approach.

If we compare the limitations of the past with the geometric expansion of today, studying the historical antecedents of Brazilian science may seem an idle academic exercise. However, the scientific advancement so characteristic of the present is led by a generation of scientists who obtained degrees in the 1930's and 1940's, when the present Brazilian university system was being shaped. This formative period rests in turn on Brazil's historical heritage, which is our starting point.

Historical Background: Science and Education until 1900

The colonization of Brazil was a chapter in Portuguese commercial operations, which had its highest stakes in India, and only much later in the Americas. Contrary to the Spaniards, who attempted to transpose their administrative, cultural and religious structures to the new continent, the Portuguese created only those institutions necessary for the development and protection of their economic interests. In colonial times, the main educational establishments were Jesuit colleges. Contrary to Spanish America, Brazil did not have a full-fledged university until the twentieth century.

Brazil's colonial status ended in 1808, when the Portuguese royal family under British protection fled from the Napoleonic troops to Rio de Janeiro. British influence dominated Brazilian foreign trade and international relations from then until at least the First World War.[9] At the same time, the presence of the Portuguese court in America meant that Brazil was granted the right to have a few institutions of higher learning and technical orientation for the first time in its history. In short succession, courses of medicine were organized in Bahia and Rio de Janeiro; a Botanical Garden was created in Rio, together with a National Library, Military Academy, and Museum. These institutions, along with the Law Schools of São Paulo and Recife (1827), were the only ones offering science and higher education in Brazil until the last decades of the nineteenth century.

The background of these first technical establishments should be examined in the context of what is known in Portuguese history as the "Reforma Pombalina," the reforms introduced in the University of Coimbra by D. José I's Prime Minister, Marquis de Pombal, in 1772. Attendance at Coimbra to receive education and professional accreditation was mandatory for members of the Portuguese elite who aspired to high positions in public life. Until the middle of the nineteenth century, most of the Brazilian elite sent their sons to study at Coimbra's Law and Medical Schools.[10] Pombal's reform was a profound, if belated effort to modernize the university and bring Portugal into the mainstream of European economic, technical and cultural development. Portugal's marginality dating from the early eighteenth century was due to complex processes that made it politically and economically dependent on Britain. At the same time, the counter-Reformation, the Inquisition, and the militancy of the Jesuits kept the country isolated from the intellectual and cultural influences sweeping Europe. Under Pombal, the Jesuits were expelled from the Portuguese Empire, the teaching of scholastic philosophy was banned, and the University of Coimbra was enriched by a school of mathematics and natural philosophy, laboratories of chemistry, physics, pharmacy, and anatomy, and the arrival of foreign teachers, mostly Italian.[11]

The established Church's resistance to reforms and to free-thinking had clear political implications; it meant the political economic, and physical suppression of those who did not conform to the centralized authority of a state, which in turn the Church subdued. Pombal's reform sought to free the state from the authority of the Church, but within an authoritarian and centralized political context. The introduction of modern science into Portuguese culture was essentially a political and administrative act, a kind of "revolution from above," which encountered substantial resistance. Thus, Portugal did not have the type of spontaneous flourishing of scientific activities and institutions that characterized the emergence of science in Italy, France or England. In other words, there was no scientific community. The purpose of the reform was eminently practical and utilitarian, allowing no role for free experimentation, speculation, and research.

If in the previous period instruction had been based on the minute regulations enumerated in the Jesuits' Ratio Studiorum, now the Pombal government prescribed how scientific principles should govern the teachings of medicine, engineering, or geology. In sum, Portugal's drive for modernization was the work of a political and administrative secular elite, which attributed Portugal's backwardness to the Catholic Church and its grip upon the country's educational and cultural institutions.

Though never eliminated in Portugal or Brazil, the presence of the Catholic Church and its role as the guide for the country's cultural and political life was from then on strongly curtailed. At the same time, the authoritarian and wholly pragmatic way in which modern science was introduced in Portugal placed clear limits on the kind of scientific activities that could be accepted and stimulated.

Throughout the nineteenth and even throughout this century, these features have had a lasting influence in Brazil.[12] The identification of the Catholic Church as the enemy made most of the Brazilian intellectual and political leadership look to France as a source for inspiration.[13] It is puzzling why the French intellectual tradition in Brazil was so much more important than the British one, especially given Britain's dominant economic presence. A partial answer is that France's drive to build a modern, efficient, and secular state after the Revolution was more politically meaningful to the Brazilian elite than the intellectual and cultural climate of England. England's orientation at the time was towards the development of a capitalist, privately based society, where economics took precedence over politics and sociology. British influence existed where capitalist activities flourished; but these were, of course, very limited in nineteenth century Brazil.[14] France and, in a lesser degree, Belgium, replaced Portugal as the country where Brazilian students went to study and to bring back modern ideas. In spite of the Church's stern opposition, Freemasonry flourished among the elite, and Auguste Comte's positivism became its preferred ideology.

Brazil is probably the country where Comte's positivism was taken most seriously. Later in the nineteenth century, most of the faculty of the School of Engineering and the School of Medicine in Rio was positivist. Positivism was pervasive in the Brazilian army. It was the ideology of a substantial part of the country's political elite in Rio de Janeiro and Rio Grande do Sul, which was so active in the establishment of the Republic in 1889. A Positivist Church was established in the country, and its leaders regularly corresponded with Emile Littré, in Paris, about questions of positivistic orthodoxy.[16]

To understand how European liberal ideas were understood in Brazil, one should bear in mind that Brazil was a slave-based agricultural economy until late in the nineteenth century. An active political, cultural, and intellectual life flourished only in a few urban

centers--Rio de Janeiro, Salvador da Bahia, Recife, Porto Alegre. Liberalism, republicanism, evolutionism, and positivism were banners used in the political battles that shifted leadership from the north to the south, from the landed aristocrats to the city bureaucrats, from the civilian to the military, and from the old to the new generations. But they never were meant to open the country's social and political space to emerging social groups--industrial workers, middle classes, professional groups--simply because these groups were too weak and disorganized before the industrialization drive of post-1930.

Positivism provided the country's civilian leadership with an ideology compatible with Pombal's anti-clericalism. It was a closed system of thought that had its own orthodoxy, and did not leave room for the vagaries of free thinking and speculation; thus it favored technical and applied knowledge over experimental science. If Positivism embraced republicanism, it was an authoritarian variety, which aimed to develop society through enlightened dictatorship, and which distrusted the formal trappings of democracy.[17] Finally, Positivism conferred upon those who embraced it a clear sense of being modern, in favor of science, and oriented towards the future, rather than obscurantists who looked to the past.

Comte's positivism led easily to an anti-scientific posture.[18] Positivists were against the universities, a system of "pedantocracy" for which they saw no use. Since Comte had already arrived at the Great Synthesis, the universe of knowledge was viewed as closed, with no room for new theories, concepts or research.[19] Teaching was usually dogmatic in the professional schools of the 19th century Brazil, a formalistic, ex-cathedra exercise, based on old textbooks of poor quality, and the positivistic rhetoric attached to it seldom improved its quality. Lack of competition among different schools, an absence of a scientific and technical tradition that maintained higher standards, and society's limited demands for technical skills from its doctors and engineers are the major factors that explain this state of affairs.

As contacts with Europe, and later the United States, increased, so did the sources of new ideas, orientations and standards of work. One important element in keeping these contacts open was Pedro II, the Brazilian Emperor from 1840 to 1889. As an enthusiastic supporter of modern technology, he brought foreign scientists to the country to help establish research institutions. For instance, he was directly responsible for establishing the School of Mines in Ouro Preto, based on the French model and operating under a French director, H. Gorceix; he also organized the Brazilian National Observatory, also run by a Frenchman, H. Morize. The emperor set up several of the National Museum's research laboratories and he willingly cooperated with foreign scientific expeditions.[20]

The list of foreign scientific expeditions in Brazil is large, and includes some important names--von Langsdorff from Russia; Auguste de Saint-Hillaire from France; von Eschwege, von Spix, von Martius, from Germany and Austria; Alfred Wallace, Henry Bates, and Darwin from England; and the Tayer Expedition from the United States with Luis Agassiz and his collaborators, some of whom, such as Charles Hart, and, most importantly, Orville A. Derby, remained in Brazil. Hart later organized the Brazilian Imperial Geological Commission in 1875; Derby established the Geographical and Geological Commission of São Paulo in 1886, and became the most preeminent scientist in Brazil in the area of geo-sciences. Other foreign scientists working in Brazil during the 1880's and 1890's included Fritz Müller, who contributed to the empirical consolidation of evolutionism; Emile Goeldi, organizer of the Museum of Natural History of Pará, in the Amazon Region (18903); Herman von Ihering, organizer of the Museum of Natural History of São Paulo (1893); Louis Couty, who worked with J. Batista Lacerda in the Laboratory of Experimental Physiology of the National Museum in Rio; and F. W. Dafert, who organized the Agronomic Station of Campinas, São Paulo, the first agricultural research center in the country (1887).[21]

The Turn of the Century: Pure vs. Applied Science

The shift of Brazil's economic and political center of gravity from the Center-North to the Center-South of the country--and most especially to the São Paulo area--was ultimately responsible for the demise of the Imperial regime and the installation of the Federal Republic in 1889, a year after the abolition of slavery.[22] Profound changes occurred in many areas of activity, including the fields of science, technology, and higher education. There was an increasing feeling that the country was entering the new century as a modern society, to which science could bring its benefits. From 1890 to 1910, for example, several research and training institutions were established throughout the country, primarily in São Paulo, to expedite its modernization: bacteriological institutes (in Rio and São Paulo); agricultural research centers (São Paulo); schools of engineering, pharmacy, veterinary medicine (in São Paulo, Porto Alegre, Rio de Janeiro); meteorological and geological services at state and national levels.

The spectacular results of the work against malaria, yellow fever, and other contagious diseases dramatically demonstrated the immediate benefits that science could bring. The drive was organized by the bacteriological institutes of Rio and São Paulo, established in 1892 and 1900.[23] Adolpho Lutz, born in Brazil and trained in Europe, started the work in Sao Paulo; the Instituto Oswaldo Cruz in Rio de Janeiro expanded the drive to a national level a few years later. In a short time, the sanitization of Rio de Janeiro and other areas had been completed, and this achievement established beyond a doubt the prestige of scientists in society.

The close contacts between the Instituto Oswaldo Cruz and the Institute Louis Pasteur (where Oswaldo Cruz himself was trained), the international recognition of the Institute's work, and the freedom of movement that resulted from its successes helped the Institute become a true scientific center. At its core the Institute emphasized pure research on the theory that practical applications would follow. This attempt did not succeed in São Paulo where the pressure for strictly practical activities prevailed; and in the first decade of this century Rio's Institute was the main scientific research institution in the country.

Lack of international contact, bureaucratic factors, and new discoveries that mooted the Institute's work account for its decline after its first fifteen or twenty years. While the Institute's domestic prestige lingered, its international prestige faded, a situation hardly conducive to an intensive interchange with foreign institutions. When authority for the Institute was transferred from the university to the Ministry of Health, the bureaucracy's tendency to favor routine and practical activity alienated those staff members who favored pure research. Once the staff was established, there was little room for innovation and personnel changes as an increasingly bureaucratized national administration reduced the freedom of decision and maneuver the Institute had enjoyed in the previous years. The final blows came in the 1930's, when the discovery of the sulfa drugs made much of the practical work of the Institute in the area of serum and vaccine production obsolete.

Other attempts to develop scientific traditions from applied activities met mixed success. The Brazilian Geographical and Geological Commissions, organized by Derby in the 1890's as institutions devoted to scientific research, became unproductive, bureaucratic organizations. Some success, however, was achieved by several institutions in the São Paulo area related to the Oswaldo Cruz Institute. The Butantan became famous for its work on snake venom; and the Biological Institute, directed by a German-trained scientist, Rocha Lima, managed to control a blight in the coffe plantations.[24]

The early history of the Agronomic Institute of Campinas is a good example of the difficulty of basing scientific development on success in solving practical problems. At the turn of the century, São Paulo was the center of an expanding coffee economy, based on cheap fertile land, cheap labor and a virtual monopoly in the world's coffee trade. There was thus little agronomic research for the improvement of species or better use of the soil simply because such research did not make economic sense.

Research on other agricultural products was also a waste of time. The first director of the Institute, F. W. Dafert, an Austrian chemist, left São Paulo when he failed to convince the paulistas of the utility of his work. He returned to Vienna to become the head of an experimental research station in agricultural chemistry. The Biological Institute, established in 1927, was luckier; it identified and controlled the coffee broca

(Hypothenemus hampei), a very destructive blight that was crippling the plantations. The ability of its scientists to build a successful research center upon this lucky start reminds one of the way in which the Oswaldo Cruz Institute was created almost thirty years before. The fact that these scientists had been part of the Oswaldo Cruz tradition of biological research--rather than chemical or agricultural researchers--was also very important, since they had a model to apply and a social image from which to work.

Between 1910 and 1930, several German researchers and specialists were invited to establish chemistry courses in Minas Gerais, Porto Alegre, and Rio de Janeiro, but without significant results. In the absence of a developed industrial sector, well-trained chemists were not in demand and the university system, geared to the practical professions, did not see the value of developing an independent chemical research center. Medical and pharmacological research, such as that undertaken by the Baeta Viana group in Minas Gerais, and at the Butantan and Biological Institutes in São Paulo[25] fared better.

A brief history of the Brazilian National Observatory further illustrates the relationship between pure and applied science. Established as a section of the Rio Military School in 1827, its work did not get underway until 1850, when its first instruments were obtained, and routine observations begun. Emmanual Liais, a French astronomer who had previously worked in the Paris Observatory and who Pedro II had invited to join in the expeditions observing the solar eclipse of 1858, became its director in 1870. With Liais, the Observatory became independent from the Military School and secured advanced equipment from Paris that was more suitable for studying the orbits of planets and comets and for developing a precision chart of Brazil. Louis Cruls, a Belgian astronomer who cooperated in this work, succeeded Liais in 1881. Upon his death, in 1908, the post was taken by Henrique Morize, also French by birth, but educated in Rio de Janeiro; he headed the Observatory until 1930.[26]

The tradition of research started by Liais was never fully understood in wider circles. In less specialized sectors, astronomical studies tended either to be identified with the popularized, romantic image that derived from the works of the French astronomer Nicholas C. Flammarion or to be considered as a wholly practical activity involving meteorological observations and the determination of time and distances. The latter tendency prevailed, and in 1909 the Observatory was placed under the Ministry of Agriculture, as a section of meteorology and astronomy. Morize developed an efficient system of meteorological observation, which permitted him sufficient freedom of movement to continue his astronomical research.[27]

Henrique Morize's importance extended beyond his achievements in astronomy. He was a professor of general and experimental physics at the Polytechnic School of Rio de Janeiro, formerly a branch of the old military academy. His thesis, submitted in 1896, was on cathodes and X-rays. He founded the Sociedade Brasileira de Ciencias in 1916,

which later became the Brazilian Academy of Sciences, and he served as its president for its first ten years. Together with Otto de Alencar, a mathematician who had been teaching at the Polytechnic School since 1902, he challenged the Positivist intellectual supremacy at the school and helped to advance a social movement for science, education, and a true university that influenced the country for many years.

The Challenge of Positivism and the Movements for Science and Education

A peculiarity of the Brazilian history was that Positivism not only was a general scientific ideology for the country's intellectuals and politicians, but also bore directly on the contents of the courses and on the technical training provided by the military and engineering schools. Comtian orthodoxy was considered the ultimate element of mathematical proof, and established external limits to what the mathematicians could do. For the brightest young students of the Polytechnic School in Rio, the imported French books containing the more recent advances in mathematics and physics were read with excitement and a taste of subversion against the university authorities. In a series of articles published in France, Portugal and Brazil, Otto de Alencar exposed the mathematical inconsistencies of Comte, and showed how he tried to stop the development of the discipline, by ruling as "metaphysical" such topics as the theory of numbers, the theory of probabilities, the calculus of elliptic and discontinuous functions, and so on. In Europe, mathematics advanced in spite of Comte. In Brazil, however, the debate between modern and positivist mathematics was a long one. In 1925, when Albert Einstein visited Brazil, the professor of Rational Mechanics from the Polytechnic School, Licinio Cardoso, published an article entitled "Imaginary Relativity." By then, positivism had been defeated as a philosophy of science; however, its political and social presence continued.[28]

The Brazilian Sciences Society, established in 1916 by H. Morize, was the country's first attempt to institutionalize science as an independent activity. The society collaborated with the Brazilian-French Institute of High Culture and published the Journal of Sciences. The name changed in 1922 to the Brazilian Academy of Sciences but the organization continued to hold conferences featuring well-known European scientists and actively to promote scientific values.

More active and vocal than the Academy was the Brazilian Association for Education (Associação Brasileira de Educação--A.B.E.). Created as a voluntary association of scientists, educators and intellectuals, its leadership overlapped with the Academy's. The A.B.E. promoted conferences, debates, seminars and publications, which raised the country's social consciousness about modern educational issues. Among the Association's most significant activities after 1927 were surveys of the country's educated elite regarding the educational needs of the country and the organization of several influential national conferences on education.[29]

The Association was a heterogeneous group, more concerned with being a forum for discussion of educational issues than with implementing a particular philosophy. In time, some preferences crystallized. In the field of general education, the dominant figure was Anisio Teixeira. Influenced by the American pragmatists William James and John Dewey, Teixeira brought the idea of mass public education and modern pedagogic methods to Brazil. The conflict with Catholic sectors was unavoidable. Teixeira and his followers were dubbed as communists and atheists, but they nevertheless helped to shape the country's educational system.

In the field of higher education, the leadership provided by the group that also belonged to the Academy was undisputed. They all agreed that a true university should be established in the country, organized around a School of Sciences, and based upon the principle of academic autonomy with a clear distinction between professional training and scientific research. The University of Brazil, which had been established in 1920 by joining several independent, uncoordinated professional schools, was not perceived as performing these functions.

The fate of the movements for public education and for a new university is closely related to the political changes Brazil experienced after 1930. These educational priorities merged with a more general movement for the country's modernization, which drew its support from the main urban centers. The twenties were the last decade of the so-called "Old Republic," a regime that placed most political decisions in the hands of small state oligarchies and old-fashioned military hierarchy. Dissatisfaction was widespread among young military officers, professionals, intellectuals and the emerging bourgeoisie of São Paulo. The new regime established in 1930 was an heterogeneous composition of old and new political elements. It drew upon a group of young leaders who replaced the old guard. This new group, composed of military officers and some civilian leaders, was recruited from the leadership of the states supporting the insurrection. One of those was Getulio Vargas, from Rio Grande do Sul. Conspicuously absent were the more vocal groups in Rio de Janeiro and practically all sectors of the state of São Paulo; they had supported the losing side.

The new regime progressively institutionalized the structures of an authoritarian state. The Vargas dictatorship built upon the Republican and positivistic political tradition of Rio Grande do Sul, to create a powerful civilian oligarchy linked to the military--a combination that did not occur in other states. Authoritarianism did not mean lack of modernization. Events in Europe, reinforced by the large groups of German and Italian immigrants in Brazil, made fascism a potent model for state-building.

In the area of education, the new government incorporated many of the ideas and plans that were being developed by the A.B.E., but within an authoritarian context. The State supported national educational conferences; some of the movement's leaders were called upon to reform

the educational systems of the largest cities.[30] Later on, an important sector of the A.B.E. was institutionalized in the Ministry of Education, as the National Institute for Pedagogic Studies (INEP) under the direction of another of the movement's leaders, Laurenço Filho. Seen from today's perspective, the group of intellectuals involved in educational issues presents a surprising mixture of liberal and reactionary actions and personalities. For example, side by side with Anisio Teixeira, was Francisco Campos, who was active in the educational reform in Minas Gerais during the twenties, and who drafted the laws that structured the country's new university system in 1931. (He is better known, however, for the writing of the neo-fascist constitution that shaped Vargas' fully authoritarian regime after 1937.)[31]

The university system envisioned by Francisco Campos was generally the model the country later adopted. It paid lip-service to the ideals of creating science schools with freedom of research and granting university autonomy but these ideals were postponed until Brazil was ready for them. In the meantime, the School of Science was to be a School of Education, responsible for training secondary-school teachers. All university matters were minutely defined and settled by the National Education Council, established under the Ministry of Education.

The short-lived University of the Federal District, organized in Rio de Janeiro by the A.B.E. group, under the direction of Anisio Teixeira, was a frustrated attempt to build a university within the new framework. It had a Sciences School that complied with the national priorities of preparing school teachers, while recruiting several talented scientists to do research. The School was closed after a governmental backlash against the Communist putsch of 1935. The School of Philosophy of the University of Brazil, which never developed the conditions for scientific research,[32] absorbed some of its staff.

The State of São Paulo had a more successful project. Alienation from national political decisions and loss of local autonomy had led to a widely supported though unsuccessful uprising against the Federal Government in 1932. Leaders of the movement were exiled, but returned a few years later. As a gesture of accommodation, the Vargas regime granted the state governorship to a former rebel, Armando de Salles Oliveira. Some of the uprising's outstanding leaders--industrialist and economic historian Roberto Simonsen; newsman, Julio de Mesquita Filho (whose family owned the newspaper O Estado de São Paulo), and writer Paulo Duarte--believed that São Paulo, the richest and most progressive of the Brazilian states, could only regain national political preeminence through intellectual and cultural development.

A School of Sociology and Political Science was organized under Simonsen's leadership in 1933. It trained many of the state's future political and economic leaders in modern social sciences, in contrast with the traditional law schools. The School of Sociology was intended to be a "center for social and political culture able to raise

the interest for the common good, to establish the links between man and his environment, to stimulate research on the living conditions of our population, and to shape personalities which could cooperate efficiently and consciously in the direction of the country's social life." In contrast with the French-oriented social sciences department of the University of São Paulo established a few years later,[33] its ties with North American institutions were always strong.

The University of São Paulo was organized separately and had wider aims. The heart of the new university was to be its Faculty of Philosophy, Sciences and Letters. According to its charter, its purpose was to train teachers for the state's secondary schools. However, the recruitment of its staff was done in such a way as to guarantee the development of independent scientific research and it attracted a staff of well-established foreign scientists, who brought to Brazil their knowledge, working expertise, and intellectual traditions. They could do their own research, train their students, and at the same time, help to upgrade the old professional schools in the state, now linked to the University structure.

The recruitment of professors in the natural sciences was delegated to a mathematician, Teodoro Ramos, who had belonged to the Rio de Janeiro group that had broken with positivism. He brought an oustanding group of mathematicians and physicists, among them Gleb Wathagin, and Luigi Fantampíc (mathematics) and, for a brief period, Guiseppe Occhialini, all from Italy. The Italian government, considering this exchange an important cultural and political mission, subsidized their salaries. H. Rheimboldt, formerly a professor at the University of Bonn, organized the chemistry department; H. Hauptman followed soon after in organic chemistry. Paulo Duarte, a writer and active intellectual, influenced the recruitment of French social scientists. For different lengths of stay, Claude-Levy Strauss, Roger Bastide, Pierre Monbeing, Paul-Arbusse Bastide, Fernand Braudel and several others taught at the University of São Paulo in the first years, and helped to establish an intellectual tradition that became more important than the one developed through the School of Sociology.

The effects of the new School of Sciences on the Brazilian scientific and cultural milieu are paradoxical. From the institutional point of view, the experience was in many ways a failure: the professional schools did not accept its professors in the courses; very few high-quality students were attracted to scientific careers; and, when governor Armando de Salles lost his political power a few years later, federal pressure mounted to make the University comply with federal norms, regulations, and oversight.

At the same time, the experience gained from organizing an independent and intellectually mature scientific institution was never lost. Almost all the research traditions in the natural and social sciences that developed in Brazil in the next twenty years

resulted from the efforts of this original group. After World War II, the University of São Paulo was the only state-supported university in the country, when the Ministry of Education implemented a national system of federal universities. (Later, other state-funded universities were created, such as the University of Campinas, the University of the State of São Paulo--UNESP--and the University of Rio de Janeiro.) USP continues as the most important teaching and research institution in the country.[34]

Post-War Developments

World War II had a major impact on Brazilian society. The military involvement of the country in the war was not very large, but it provided the regime with a good reason to attempt the first program of economic mobilization and planning in the country's history. Although traditional trade relationships were upset, Brazil became a supplier of some important strategic materials for the Allies--diamonds, manganese, nickel, tungsten, and, more important, rubber. An important step in the country's industrialization process was the establishment of the steel mill of Volta Redonda, which had the technical and economic support of the United States and was part of the agreements that brought Brazil into the War.[35] The reduction of imports increased domestic demand for São Paulo's manufactured products, and created a surplus of foreign reserves. When the war ended, a constitutional government based on mass suffrage replaced the Vargas regime; Brazil's economic surplus was used to create the beginnings of a society geared to modernization and mass consumption. Once the foreign reserves were depleted, Brazilian and foreign-owned industries started to produce for the consumer demands of an expanding urban sector.

The most important effect of these changes upon the Brazilian system of higher education was a rapidly growing demand for professional training. Some of this demand arose from a real need for engineers, doctors, lawyers, and teachers in a rapidly modernizing society. A less recognized, but probably more important factor was the middle-class demand for socially prestigious positions, and for the benefits brought by professional status. Regardless of the quality of one's education, a university degree assured a certain level of social prestige and income.[36]

To meet the demand for degrees, a nationwide network of federal universities was established that absorbed the old professional schools and state university structures throughout the country and created new ones. Only São Paulo kepts its state university. In addition, a national system of private, Catholic universities developed in Rio de Janeiro (the first in 1940), São Paulo, Porto Alegre, Recife, and Belo Horizonte. Isolated, professional schools were permitted, and they sprouted throughout the country, mostly in disciplines not needing technical equipment and specialized staff training.

The federal universities under the Ministry of Education followed the general outlines of the Francisco Campos legislation, and the system of governmental oversight and curricula standardization extended to the private schools. Federal University personnel were defined as civil servants, subject to homogeneous systems of payment and job stability. Although education was free, a highly competitive entrance examination restricted applicants. Those who failed could opt for less prestigious careers, or could enroll in private schools where the quality of education and the working possibilities afterwards were inferior. Since the system of secondary education in Brazil remained mostly private, only the affluent had access to free university education, while others, who lacked a good secondary training, had little chance of being accepted.

These developments in the system of higher education did not leave much room for advanced scientific training and independent research. The country's modernization and industrialization created a job market more sophisticated than that of the pre-war period, and this gave more room to better trained professionals in all fields. At the same time, however, the new industries either bought their technologies abroad or were foreign-based themselves. Thus there was no demand for scientific and technological innovations from the universities and other research institutions.

There were, of course, a few important exceptions such as the School of Medicine of Ribeirão Preto, São Paulo. It inherited some of the scientific spirit of Oswaldo Cruz and the Biological Institute of São Paulo. With the support of the Rockefeller Foundation, it had a full-time staff that produced high-level scientific research, training, and clinical work.[37] Another exception was the Instituto Technologico da Aeronautica, a civilian engineering school established by the Air Force in close cooperation with American institutions and according to American models. Other exceptions were a few science departments and institutions such as the Biophysics Institute of the University of Brazil in Rio de Janeiro, directed by Carlos Chagas; the Institute for Radioactive Research in Minas Gerais; and the Faculty of Philosophy, Sciences and Letters of the University of São Paulo, which was the main academic institution in the country that continued significant scientific research. One of its most successful departments was Physics under the leadership of Gleb Wathagin, whose achievements are examined below.[38]

Gleb Wathagin, born in Russia and trained in Turin, worked in the field of cosmic rays during the 1920's. He witnessed the intense research activity in Europe, then developing around Bohr, Heisenberg, Pauli, Fermi, Dirac, Rutherford, and Kapitza, many of whom he knew personally. He arrived in Brazil in 1934, and after a few years started sending his brightest students to work under his European acquaintances. One of them, Mario Shemberg, worked with the Fermi group in Italy, and later with G. Gamow in the United States. Another, Marcelo Damy de Souza Santos, after working with G. Ochiallini in

Brazil, went to Cambridge, where he worked in the measurement and detection of X-rays. Paulus A. Pampeia, an electronics engineer by training and Wathagin's assistant, went to Chicago in 1940 to work under Compton, who had a joint project underway with Wathagin for the detection of cosmic rays. In 1946 two others left: Cesare Lattes, to work with Ochiallini in Cambridge, and Oscar Sala, with M. Goldhaber in Illinois.

When most of the European and North-American high-energy physicists turned to atomic energy research for the war, the Brazilian group was left out. Those who had been abroad returned to São Paulo, and were soon asked to join the Brazilian war effort. The most interesting activity of the period was the development and production of sonars to be used by the Brazilian navy for detecting German submarines. The United States had the technology but at the time was not willing to share it with Brazil. The knowledge and skills for detecting high-energy particles proved helpful to physicists for mastering sonar technology. After a period of trial and error, about 80 sonars were built in São Paulo by a combination of local suppliers and the electronics abilities of Damy and Pompeia. After the war, technological demand ceased, and academic careers could proceed along their previous course. The war had proved, however, that pure research could have important and short-term practical pay-offs, a lesson that could not be forgotten.

Hopes for entering the nuclear age captured and controlled the scientists' imaginations. The well-known history of nuclear research in Brazil will not be repeated here.[39] However it should be stressed that it was something the scientists tried to "sell" rather than a course decided upon and supported by the government. The establishment of the first experimental reactors in São Paulo, and then in Belo Horizonte and Rio, was achieved through cooperation with foreign universities and American support and was wholly geared to particle research. The attempts to build up some independent research and technological capability for atomic energy production were never endorsed by the authorities, except during the brief second Vargas government of 1950-1954. It was abandoned thereafter, probably because of North-American pressure. The country's first reactor, now near completion, is a Westinghouse model based on enriched uranium, which the United States will provide. The current atomic technology program devised in association with West Germany is a purely industrial technological project, in which academic research has little place.[40]

The idea that science and education should benefit society was, of course, pervasive after World War II, especially in Brazil, which had little experience in pure, academic research. While the general pressure in the professional schools was for the elimination of research and the downgrading of teaching, the country's academic elite grew increasingly impatient with the limits imposed upon their work. Consequently, they started to look outsdie their own walls to pressure for those values and programs they considered necessary

to free the country from underdevelopment and to resolve their frustrations with the role of scientific research in Brazil. Many became political activists, or at least active in university politics; social scientists, for example, began to direct their writings to the nation as a whole. Others tried, sometimes simultaneously, to create new institutions and policy instruments that could enable the country to build its scientific and technological autonomy. Many of the country's scientists saw roles as political activists, government advisers, and public figures as appropriate and necessary. Others, of course, preferred more specific and technically oriented roles but even for them, the need for conditions permitting normal scientific activity implied a degree of social and political participation.

Scientists in the state of São Paulo created the Brazilian Association for the Advanced of Science (SBPC) in 1949 as part of a movement to protect their research institutions against the populist politics of the state's governor, Adhemar de Barros. For many years the SBPC retained a low-profile but its role in legitimizing scientific activity in Brazil should not be minimized.[41] More recently, it widened its territorial and disciplinary scope to include new fields, such as the social sciences, and broadened its membership to scientists from states other than São Paulo. The SBPC publishes a widely read magazine, Ciencia e Cultura. Thousands of scientists and students, under the lights of the country's mass media, attend its annual meetings. The meeting agendas range from the most esoteric scientific papers, and the problems of scientific and technological policy, to public conferences and round-tables on social and political questions.

In 1961, another effort to build a modern university with a well-defined place for scientific research was undertaken in the capital city of Brasilia. In a way, the University of Brasilia repeated the frustrated experience of the University of the Federal District twenty-five years earlier. Some of its intellectual leaders were the same--Anisio Teixeira, as well as Darcy Ribeiro, who had been affiliated with the INEP, the governmental agency which inherited the traditions and aspirations of the Brazilian Association for Education. The new university adopted the North-American department and central institute organization, instead of the traditional European plan of professional schools and independent chairs. Intended as a model university, the professors invited to organize it participated in all aspects of its planning. According to all witnesses, enthusiasm and hope were high. But the new university was too closely identified with the overthrown João Goulart government, and in 1965 most of its staff resigned after a conflict with the Castelo Branco regime. The initial impulse was lost.

In spite of its problems, the University of Brasilia, with its structure of central research institutes and departments, inspired the Brazilian University system reform first attempted at the University of Minas Gerais. In 1968, the Reform was mandated by Law no. 5,540 which for the first time introduced the credit system in the Brazilian universities.

In the last few years, two distinct patterns of development have emerged. One is directed towards a general upgrading of the university system, through the implementation of the 1968 Reform and the creation of a system of graduate training. The other is essentially an attempt to abandon the university system as unfit for scientific activities. The latter trend has led either to the creation of independent, non-university research centers, or to the creation of university experiences outside the mainstream of minute regulations, pre-defined procedures and bureaucratic management, the landmarks of the system since the Francisco Campos legislation. It is this second pattern that we discuss below.

Science Development and Science Policy

In 1951, the Brazilian government established the National Research Council (CNPq) as an executive agency, with the specific purpose of fostering atomic research. One of the main functions was to support the newly established Brazilian Center for Physics Research--CBPF--in Rio de Janeiro. Both the CNPq and CBPF resulted from the personal efforts of a well-positioned and respected man, Admiral Alvaro-Alberto, a mathematician and physicist who nevertheless failed to build a full-fledged nuclear program as he had hoped. The CNPq, once established but deprived of its main objective, became a grant-giving agency that distributed its limited resources to individual scientists in the biological, physical, and other natural sciences. With its backing, a scientist could pursue independent research, even when not supported by his own university, which was usually more concenred with the problems of professional education or short-term technical demands. A similar institution later established in the state of São Paulo, the Foundation for Support for Research (Fundação de Amparo a Pesquisa--FAPESP), receives a fixed percentage of the state's budget for its activities.[42] Besides supporting research, the National Research Council provides fellowships for graduate and post-graduate studies abroad, in conjunction with CAPES, an agency of the Ministry of Education, as well as foreign governments and agencies such as the USAID, the Ford Foundation, the Fulbright Commission, the British Council, the French Government, and several others.

In brief, during the 1950's and early 1960's, the growth of the Brazilian university and research systems stagnated; there were only a few innovative experiments and these had no effect on the nation as a whole.

From the late sixties on, several important and more or less parallel developments occurred. First, there was a political decision around 1968 to ease the admission restrictions for new students and to create new establishments of higher education. The biggest increase was in the isolated, privately owned professional schools, where first-year enrollments doubled, rising from 39,000 to

85,000 in one year. Consequently in 1971 more than half of all university students were enrolled in private institutions, compared to a third in 1964. In the United States, private universities traditionally have been high level, elite institutions where only the rich could send their children. In Brazil, with a few exceptions (the Mackenzie School of Engineering in São Paulo, or the Catholic University in Rio de Janeiro), the opposite has been true. Private universities have tended to be profit-oriented, enrolling a maximum of students with a minimum of capital investment in equipment and high quality personnel. Public universities, on the other hand, have attained fairly high teaching standards. The result is a perverse situation in which the rich pay for better secondary school training, and receive higher education at free and high-quality universities whereas the middle sectors pay for inferior schooling at both the secondary and university levels.

The increase in university level openings was not followed by a corresponding effort to increase teaching facilities. The new private schools tended to provide courses in "soft" subjects, such as law, social sciences, economics, and business administration, while improvising its staff and facilities. At the same time, the public universities were flooded with applicants, many of them unqualified, who had to be accepted if there was room. To stem the erosion in the quality of education, a law was passed that required that all teachers have at least a master's degree, and that promotion be based, among other things, on the possession of a doctorate.

The effect of this decision can only be appreciated if we consider that master's and doctoral degrees were simply not given in Brazilian universities up to that time. The University of São Paulo, and to a lesser degree, other universities, followed the French pattern of granting a doctoral degree only after a long apprenticeship. Typically a doctoral dissertation followed, rather than preceded, a university career. The new legislation looked to the American system, where regular teaching programs lead to advanced degrees.[43] As new programs began to emerge, the educational authorities created a complicated system of standards in order to avoid an inflation of substandard graduate programs. For example, one of the requirements stipulated that a significant percentage of a newly created graduate program's staff had to have their doctorates.

Some aspects of the Brazilian university system, as it stood in 1973, can be seen in the table below. Sixty-seven percent of the students were enrolled in the social sciences, many in newly created schools that provided an uncertain professional future. The majority of these students were enrolled in private establishments, and their share of the country's total faculty was less than 50 percent. In the natural sciences about 30,000 of the 46,000 were enrolled in courses of mathematics, and 63 percent of these were in private schools. These mathematics students should not be placed together with those in technical fields, but rather with the large numbers of students in literature, education, and social sciences, who can

TABLE 1

STUDENT ENROLLMENT IN BRAZILIAN UNDERGRADUATE SCHOOLS, 1973

	Total Enrollment	% of Total	% of Faculty	% in Private Schools	% of Places Available in MA Programs
Education	67,700	10.4	5.8	72	4.1
Natural Sciences (physics, mathematics, chemistry, geosciences)	46,100	7.1	15.9	53	17.2
Biological Sciences (excluding medicine)	12,000	1.8	5.7	56	8.4
Social Sciences, Academic (sociology, anthropology, history, geography, philosophy)	46,000	7.1	11.2	53	11.2
Engineering	58,300	9.0	10.8	43	19.5
Health Care Professions (medicine, odontology, pharmacy, nutrition, nursing)	78,900	12.2	18.2	35	11.4
Social Sciences, Professional (law, administration, economics, library science, communications, physchology, architecture and urban sciences)	248,900	38.4	18.6	72	15.0
Agronomy and Veterinary	18,600	2.9	4.1	11	4.6
Literature	71,400	11.0	9.6	66	8.5
TOTALS	647,900	100%	100% (65,330)	60%	100% (7,050)

SOURCE: Calculated from Brazil, Ministerio da Educação e Cultura, Plano Nacional de Pós-Graduação. Figures for the last column are estimates presented in the Plan.

only find jobs in the secondary-education school system. The overwhelming majority of those in the health professions are enrolled in medicine (50,200) and odontology (14,500), which gives a good indication of how the system is geared towards status-granting degrees, and not the demands of the labor market (the number of para-medical specialists is supposed to be, on technical grounds, several times the number of doctors and dentists). Data on places in the M.A. programs for 1975 reveal two tendencies: one, an emphasis on engineering and physical sciences; and two, an attempt toward graduate training opportunities on the basis of the distribution of faculty among the different academic fields.

Some of the consequences of this new structure of graduate training can be summarized. Foreign degrees have increased their market values, as the newly created programs vied for people with the proper titles. Professional schools and universities with no previous research traditions adapted more easily to the demands of the new system than the more established ones;the University of São Paulo was probably the most affected institution in this regard. As groups which previously had worked within reasonable standards of quality were suddenly flooded with the demands of new students, new bureaucratic accreditation procedures,and increased competition for research money, the quality of their research often deteriorated. The concentration of resources in the relatively small graduate programs drew most of the talented faculty away from the undergraduate courses. The combination of an enlarged enrollment, a much wider social basis for university recruitment, and the diversion of the best talents to the graduate programs led to a substantial decline in the quality of undergraduate courses. Intended to be a professional credential for its holder in the Brazilian system, an undergraduate university degree, with the exception of medical and engineering degrees, started to lose its credibility and value in the market place, particularly in the "soft" careers such as business administration, psychology, education, and journalism. Consequently Master's degree programs, initially conceived to improve the quality of the universities' staff and to stimulate research, became a necessary step in many areas for those wanting to enter the labor market for the high-education professions. This, in turn, jeopardized the efforts to bring academic research to these graduate programs. The next logical step in this process would have been to differentiate between graduate programs leading to professional training and those leading to research and academic training. Such a distinction would have affected policies regarding accreditation and the distribution of resources. The educational authorities never took this step.

The contradictions between the new graduate programs and the undergraduate schools also should be seen in the light of the political events affecting the country's universities after 1968. In that year, extensive student political mobilization culminated in very strong reactions from the military government, which suspended the country's political constitution and started a long period of widespread repression. This was, in turn, matched by the emergence of several radical revolutionary groups, composed mostly of disaffected students. In the tense years that followed, the government viewed with suspicion the whole system of higher education, certainly a climate unconducive to productive work. This climate was also responsible in 1969 for the forced retirement of several of the country's best known scientists in the physical, biological and social sciences, who were perceived as linked to the students' politicization or simply victimized for personal reasons.[44]

These political events help explain the reluctance of governmental agencies to invest resources in the established university

structures, and the suspicion with which the new programs were received by those who had suffered from government restrictions. It would be a mistake, however, to believe that the new system of education and research that was being built at that time was a simple reaction to a particular political climate. In fact, it belonged to a deeper movement for the modernization and rationalization of the country's institutions, which had developed independently of the dilemmas of the Brazilian university system.

The authorities in the Ministry of Education were not alone in administering graduate programs. While the Ministry of Education had always supervised the undergraduate and professional schools, support for the graduate programs often came from extra-budgetary sources like CNPq and also foreign sources (such as the Ford Foundation) and AID, in the fields of the social sciences and education). In fact, since there was a considerable overlap between research and graduate-training institutions, the National Research Council developed a parallel system of graduate program accreditation, choosing to support the best of them as "centers of excellence."[45] One consequence of this system of direct and independent support to isolated, high-quality groups was that recipients had the chance to improve the caliber of their work in spite of the overall limitations of their parent institutions. At the same time, lack of knowledge, confidence, and cooperation between the elite programs and the university system prevailed.

A significant addition to this system occurred in the mid-sixties, when the Brazilian National Economic Development Bank (BNDE) created the Technological and Scientific Development Fund (FUNTEC) to support technology. The theory underlying FUNTEC was that given sufficient economic incentives private investors would develop their own technologies, rather than import them from abroad. Sixty percent of its resources (one percent of the Bank's annual investments, which amounted to several million dollars in the first years) were reserved for industrial research, with the remainder targeted for graduate programs in physics, chemistry, and engineering. In a few years, BNDE/FUNTEC became the main supporter of the new graduate programs in hard sciences and technologies. A second, more specialized agency, FINEP, functioning as a bank to finance technological and feasibility studies for the country's public and private enterprises at advantageous interest rates, has since become the primary source of support for these programs. FINEP also administers the government's Fund for Scientific and Technological Development, which, since 1970, has been included in the national budget. Both FINEP and BNDE are public enterprises, under the Ministry of Planning.

The entrance of agencies of economic development and planning into the field of science and graduate training had several major effects. The amount of resources allocated to science and technology increased dramatically. At the same time, technology was favored over the basic sciences. Grants had to be negotiated every two or

three years on a project-by-project basis, and the decision-making was in the hands of economists and planners.

The table below presents the main distribution of resources in the plans for science and technology after 1973. These figures do not correspond to actual expenditures, but to estimations based on budgetary allocations for the initial year, and projections of the same kind for the years that follow. Thus, they tend to be more realistic for the first years of each plan (1973 and 1975) than for the others.

TABLE 2

BRAZIL: NATIONAL PLANS FOR SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT
(Percentage of Resource Allocations)

	1st Plan (I)		2nd Plan (II)		
	1973	1974	1975	1976	1977
Atomic Energy	9.0	9.7	5.4	6.3	7.0
Other Technologies (space, marine research, non-conventional sources of energy [II])	6.5	7.3	4.7	4.5	3.5
Technologies of Infra-structure (electric energy, oil, transportation, communications)	9.9	9.5	12.2	14.0	13.9
Industrial Technology	28.0	28.8	20.8	19.4	20.0
Agricultural Research (agriculture, cattle-raising, forestry, fishing, meteorology [I])	10.8	11.4	12.3	13.6	14.8
Technologies for Social & Regional Development	4.7	4.8	8.5	6.7	6.9
Scientific Development, Development of Scientific Human Resources, Graduate Training	22.3	21.0	27.3	26.2	25.6
Others	8.1	7.5	8.9	9.1	8.2
Absolute Value in Millions of Dollars	323.4	379.4	680.0	767.1	824.8

SOURCE: Brazil, Ministry of Planning, I and II National Plans for Scientific and Technological Development. Dollar values estimated using 1975 as a basis when Cr $10,00 was equal to US $1.00. compensated by cruzeiro, not dollar, inflation.

To understand the significance of these figures, it is important to consider the expected origin of these resources. For the period 1973-74, 65 percent came from the budgets of different ministries and other federal agencies, upon which the planning ministry did not have direct influence. Twenty-three percent originated in agencies such as FINEP, National Research Council and BNDE/FINDEP. Less than 5 percent came from foreign sources. For the next period, the percentage allocated to autonomous ministries was reduced to 43 percent, while the amount handled by the planning agencies increased to 32 percent. Foreign resources remained below 5 percent.

These data suggest a tendency to concentrate resources in agencies that can support science and technology on a project-by-project basis, instead of having them scattered throughout the different ministries and government agencies. The breakdown by objectives is not ideal, since what appears under "Scientific Development" is naturally distributed along the first six substantive areas and includes also social sciences, medical research and other university-based fields. However, the data show a clear trend to move away from scattered projects of industrial research to concentrate on scientific training and university research, research projects in the areas of infrastructure, and agricultural research. There is also an improvement in resources allocated to problems directly related to the social conditions of the country's population which is the biggest increase in relative terms (a total of 55 percent from the first to the second plan), although small in absolute terms. Finally, the rate of growth in resources for the five years averages 26 percent per annum--double the country's peak growth rate in the early seventies. However, a significant portion of this growth is accounted for by the almost 80 percent increase between the two plans. This can be explained mainly by the inclusion of new expenditure items in the second plan. More significant is the increased allocation to the planning agencies, whose budget went from 88 million dollars in the first plan to 219 million dollars in the second plan, which increased their share of the total resources from 23 to 32 percent.

The most recent change in the system of support for science and technology was the transformation of the National Research Council in 1975. Its name was changed to "National Council of Economic and Scientific Development," and it became part of the Ministry of Planning, while being granted financial and administrative autonomy to hire personnel and allocate resources. From the beginning, it worked closely with FINEP, from which it received substantial resources (FINEP also channeled resources to fellowship programs developed by the Ministry of Education through agencies like CAPES). The Council coordinated and planned the country's scientific and technological policy and published the Second Basic Plan for Scientific and Technological Development for 1975-77 as its main policy instrument.

Present and Future Trends

The so-called "Brazilian miracle" of the early seventies had evaporated by 1975-77, resulting in a similar decline in resources, people, and institutions dedicated to science and higher education. The agencies responsible for financing the permanent costs of the most expensive research and training programs in the country had few resources with which to initiate new projects. For the first time, problems of priority had to be confronted. Inter-agency commissions and entities were established which developed uniform standards for fellowships, grants, and program evaluations. The result was an increase in bureaucracy, fewer opportunities for bold, innovative projects and less flexibility, but also greater stability of resources and more equality of salaries throughout the country. At the same time, a lid was placed on the creation of new undergraduate courses, while some attempts were made to upgrade the existing ones. In short, Brazilian science and technology began to experience the benefits and drawbacks of institutionalization.

Having traced recent developments, some evaluation is in order. Is Brazil better off scientifically than it was ten or fifteen years ago? Is Brazil better endowed technologically than it was before? Is its university and scientific establishment in a better position than in previous years? Who benefits from it?

If we look at Brazil in the context of Latin America, it is obvious that its system of scientific research and graduate training is today the best on the continent. Argentina's edge, based on an older and more developed university system, has been lost in the institutional chaos of the post-Peron period. This does not mean, of course, that the gap in scientific development between Brazil and the leading industrial nations has necessarily diminished. Nor does it imply that a stage has been reached where self-sustained work and growth can be expected in the future. The scientific establishment in a country like Brazil is too dependent on short-term financial support. This support is often decided outside the scientific community's sphere of influence. An across-the-board decision to limit foreign imports or travels abroad, such as the one taken a few years ago, can have disastrous effects. The quality and relative success of the Brazilian scientific institutions can be measured by indicators such as publications in international journals, number of people with doctoral degrees, and consensus of the international community about the stature of Brazil's scientific institutions. How much all this reveals in terms of technological benefits for the country is an altogether different matter.[46]

Achievements in basic science can be measured by indicators of academic excellence; achievements in technology, however, should be evaluated in terms of their social and economic impact. In the developed countries, the larger part of the resources for science and technology go to the applied fields; in the developing countries,

the opposite seems to be the rule.[47] The figures in the Brazilian plans for science and technology seem to show that, at least in budgetary terms, there is an attempt to approach the pattern of expenditures of the developed countries. More significantly, the amount of resources from the National Fund for Scientific and Technological Development allocated to the technological development of "national firms" increased from about 10 percent in 1975-76 to 52 percent in 1977 (or about one hundred million dollars). There is so far no evidence, however, that these efforts to develop applied knowledge for the benefit of the business sectors are actually paying off.

It is common knowledge that Brazilian industries, public or private, usually have shown little interest in research and development. There is a good economic reason for that: it is normally cheaper to buy well-developed technology abroad than to try to develop it at home. Foreign technology is already developed, tested, and therefore reliable. The Brazilian pattern of economic growth has always emphasized the free admission of foreign capital, enterprises and technology. This pattern not only makes it easy to import well-developed technologies, but also makes it possible to survive in the competitive, international market place. Given this situation, it is meaningful to ask whether it is efficient to devote resources to build up technological capability in the business sector.

An implicit assumption of many investments in technology is that, if good products and processes can be obtained, they will somehow become socially or economically useful. Experience indicates, however, that this is not the case. Technological research within a university or a research institute is relatively cheap and inconsequential. The adoption of a product in the market place is an altogether different matter. For example, it is technically possible to produce milk from soybeans, which is equally nutritious and cheaper than cow's milk. However, one must confront the milk producers' lobby before marketing the soybean substitute. Similarly, Brazil could develop a significant pharmaceutical industry based on national know-how and natural products; however, it would require dislodging the multinational firms that control that sector. Finally, the technology for the substitution of gasoline by sugar-cane alcohol is well-established; however, this conversion affects the car industry, the oil companies (including the state-owned Petrobrás), the agricultural sector, and the international sugar market, and is thus not easily achieved.

What can be done? A simplistic response would be to adopt a highly protective import policy that would encourage the development of indigenous technology. Pursuing a policy of international isolation for purpose of technology protection is both unwise and unlikely, barring extreme changes in internal and international conditions. Yet Brazil does need to develop its native technological capacity if it is to end the continuous outflow of hard currency for technological how-how, establish an autonomous energy policy, and develop a capital-intensive industrial system.

In this sense, the presence of technically competent groups and a reservoir of technical expertise offer alternatives to decision makers that would otherwise not exist. For instance, a recent decision to protect the mini-computer market for Brazilian firms would not have been possible without several years of previous investment in the development of experimental computers at the University of São Paulo and the Catholic University of Rio de Janeiro. Alternative energy policies could eventually derive from the availability of new or adapted forms of non-conventional sources of energy--the sun, the wind, sugar-cane alcohol--and this subject is attracting many research groups in different parts of the country. The development of technological capability at the universities can create institutional bridges between research centers and the industrial sector.[48] Finally, participation in technological projects is a crucial means for training scientists and engineers, regardless of the final social and economic utilization of their products.[49]

Criticism of Brazil's recent scientific build-up has been abundant, and usually falls in two categories. First, some criticize the emphasis on training scientific personnel as an attempt to create a new class of mandarins. The high salaries paid, the facilities for travel abroad, the use of English as a language for publication, the scientists' proclivity for research instead of teaching, and the preference of many for research that is more intellectually attractive and prestigious, while disregarding the useful and practical, are perceived as setting a clear pattern of alienation, presumption, and contempt for the country's needs. Second, critics say that if the country does not have the proper political and social policies, then the development of its technological capability can only reinforce the present patterns of underdevelopment and international economic dependence.[50] In its cruder form, this position implies that the Brazilian scientific development is a zero-sum game which, in recent years, has been played for the sole benefit of the multinational corporations.

The generalized concern for applied results, both from the left and right of the political spectrum, led to the tendency to look at science and technology through the glasses of the economists, and consequently to disregard the need to create a much stronger and well-established educational system in the country that could give the scientific community a basis for social recognition, long-range continuity, and greater impact. As we have seen, the combination of an enlarged undergraduate system with the concentration of talent and resources in the graduate and research programs has led to a general deterioration in the quality of undergraduate teaching. In the thirties and forties, the secondary school often was where young people were inspired to pursue scientific careers; it is likely that a student now will not be exposed to a challenging environment until the master's level. Although there have been no systematic studies about this, there is a generalized complaint among those involved in graduate training that it is more and more difficult to get properly motivated and reasonably trained students for their programs. One important

ingredient in the reevaluation of Brazil's scientific and educational system is the attempt to make the research and graduate programs more related and responsible to the universities where they exist. This is not a simple task, since the risks of submerging high-quality and efficiency-oriented programs in the bureaucratic, financial, eudcational, and administrative maze that is the Brazilian university system are all too real. But an active presence of the scientific community in undergraduate activities seems to be the only way to attempt to break the maze and upgrade the universities.

Proper attention to undergraduate training should rapidly evolve into a concern for secondary and primary education. This is, of course, an issue too complex to be treated here. It is enough to point out that the disregard that exists towards the undergraduate courses increases as one goes down the educational ladder. Secondary schools in Brazil are, at their best, cramming institutions to prepare students for the university's entrance examinations. At their worst, they provide ritualistic and poorly conceived courses granting degrees which lead nowhere. There is little doubt that a recent educational reform, aimed at offering technical skills leading to high-school level professions, has failed. The problems with primary education, now mandatory for all youngsters in the country--but only moderately effective in the urban centers--are too many to be listed here.

In retrospect, the recent expansion of science, technology, and higher education in Brazil stems from a combination of several, interrelated trends: an increasing demand for professional university degrees, an increasingly strong and active scientific community, and the involvement of agencies of economic planning in the field of science and technology. To each of these trends correspond different institutions, people, and mentalities. They are not necessarily compatible, and often clash, as we have shown. Moreover, scientific development in Brazil is hindered by the lack of a consistent social and economic policy based on the use of internal technological resources, by the problems besetting an inflated professional undergraduate university system, and by the general reduced power and institutionalization of the scientific community vis-a-vis the decision-making authorities in the areas of education, science and technology.

This situation is made still more difficult by the fact that historically, science has never been a career of choice for the children of the Brazilian elite, nor for its most successful upwardly mobile group. There was never a group similar to the Samurai in Japan, or the German intellectuals of the nineteenth century, that staked its social prestige and acceptance in the development of the country's scientific institutions. On the contrary, Brazilian scientists, more often than not, came from immigrant families and scattered intellectual sectors that never added anything comparable to the scientific movements of other countries. Biomedical sciences, in proximity to a traditional profession, medicine, endowed its research with stronger social support, but also gave it a lack of independence. In other areas, scientists

tended to be perceived by the country's elite as a group of middle class, sometimes foreign-born intellectuals who were little understood and often demanded too much support and privileges for their activities. The country's political and administrative elites wanted the benefits of technology, and always had some notion that, in order to do that, science should be supported. This was seldom translated, however, into a clear understanding of what is scientific activity. As in the fable, the golden eggs were wanted, but the hen--with its own values, working methods, and institutional forms of interaction--tended to be sacrificed.

Given the sheer size of the country's scientific and educational establishment, as well as its ongoing debate about the proper ways in which the scientific and technological activities should be organized and directed, the present situation is much more complex than before. It would be illusory to try to find a more elaborate and comprehensive policy behind the recent developments. In fact, the relative abundance of resources allowed governmental agencies to act independently, wihtout much interference from above. This interference only occurs when the regime perceives a political challenge, as it was in the case of the Annual Meeting of the Brazilian Association for the Advancement of Science in 1977, and the university students' demonstrations in the same year, or when budget or balance-of-payment considerations lead to financial restrictions that affect the scientific and educational activities.

The transition from a state of geometric growth to a state of stability or even reduction of resources--the end of the miracle--is certainly bringing the options to the fore, putting the whole system increasingly under stress. Attempts to rationalize, streamline, and improve the efficiency of the investments in the areas of science, technology, and education can easily lead to disaster. The multiplicity, lack of coordination, and redundancy of the several agencies supporting science and higher education have been crucial for the creation of innovative groups side-by-side with traditional university establishments. The coordination of all these agencies and their resources into a comprehensive program, through a superimposed bureaucracy, a series of coordinating committees, or other means, can have fearsome consequences. If the historical tradition is to prevail, this situation can sacrifice long-term scientific and educational goals for short-term political, financial, and economic interests. There is a chance, however, that the sheer size and quality of the present scientific community in Brazil can give it a stronger and more legitimate presence in the decisions that are about to come, helping to construct a better future in which the practical products of science and technology can be more effectively directed to the satisfaction of human needs.

Washington, April, 1978

REFERENCES

[1]Data from the Ministry of Education, Servico de Estatisticas da Educação e Cultura, with projections for 1976 and 1977.

[2]Brazil, Ministerio da Educação e Cultura, Departamento de Asuntos Universitários, Situação Atual de Pós-Graduaçao no Brasil, 1975, CAPES, 1975.

[3]Brasil, Presidencia da Republica, II Plano Básico de Desenvolvimento Científoco e Techológico (PBDCT), 1975.

[4]For a description and critical evaluation of program see Normal Gall, "Atoms for Brazil, Dangers for All," Foreign Policy, 23, Summer 1976, 155-201, and William W. Lowrance, "Nuclear Futures for Sale: To Brazil from West Germany, 1975," International Security, 1, Fall 1976.

[5]Mostly with fellowships from the Ministry of Education (DAU/CAPES) and of the Brazilian National Research Council (CNPq). For the patterns of study abroad and return of Brazilian graduate students see S. Schwartzman, Projeto Retorno--Avaliação do Impacto do Treinamento, no Exterior, de Pessoal Qualificado (Rio, Instituto Brasileiro de Relações Internacionais, 1972).

[6]For an historical view of science and technology in the Brazilian plans, see Eduardo A.A. Guimaraes and Ecila M. Ford, "Ciencia e Tecnologia nos Planos de Desenvolvimento--1956-73," Pesquisa e Planejamento Economico, 5, 2, 1975, 517-560.

[7]R. Bielschowsky, "Notas sobre a Questão da Autonomia Tecnologica na Economia Brasileira," Dados 16, 1977.

[8]Cf. V. Sant'Anna, Ciencia e Sociedad no Brasil, University of São Paulo, 1974 (M.A. dissertation); and Regina L.M. Morel, Considerações Sobre a Politica Cientifica e Tecnologica no Brasil, University of Brasilia, 1975 (M.A. dissertation).

[9]Cf. Alan K. Manchester, British Pre-eminence in Brazil, Its Rise and Decline (Chapel Hill, University of North Carolina Press, 1933); and "The Transfer of the Portuguese Court to Rio de Janeiro," in H. H. Keith and S. F. Edwards, eds., Conflict and Continuity in Brazilian History (Columbia, South Carolina: University of South Carolina Press, 1969). See also Richard Graham, Britain and the Onset of Modernization in Brazil, 1850-1914 (Cambridge: Cambridge University Press, 1968).

[10]For the education of the Brazilian elites in the 19th century, see José Murilo de Carvalho, Elite and State-Building in Imperial Brazil (Ph.D. dissertation, Stanford University, 1974).

REFERENCES

[11]The lines of continuity between the Pombal reforms and the positivistic ideologies in Brazil in later years has been stressed in several writings by Antonio Paim (see note 16, below). For the reforms, Cf. Antonio Jose Saraiva, Historia da Cultura em Portugal (Lisbon: Editora Jornal do Foro, 1955) and A. Inquisição Portuguesa (Lisbon: Publicações Europa-America 1956). Cf. also Hernani Cidade, "A Reforma Pombalina da Instruçao," in Lições de Cultura e Literatura Portuguesa (Coimbra, 1969), vol. 2; and Mario Dominbues, O Marquês de Pombal e Sua Epoca (Lisbon, ed. Romano Torres, 2nd edition, 1963.

[12]At the time of Pombal's reform, a short-lived Scientific Society was established in Rio de Janeiro, sponsored by a Brazilian Viceroy, Marquis de Lavradio, which dealt, among other things, with questions of production of a marketable dye, cochineal. See Moreira de Azevedo, "Sociedades Fundadas no Brazil desde os tempos coloniais até o começo do atual Reinado," Revista do Instituto Histórico e Geografico do Brasil, 68,2,1885; Alexander Marchant, "Aspects of the Enlightenment in Brazil," in Arthur P. Whitaker, ed., Latin America and the Enlightenment (ea. ed., Ithaca, 1961); and Dauril Auden, Royal Government in Colonial Brazil (Berkeley: University of California Press, 1968), p. 376 and ff.

[13]France also provided cultural ammunition for the Brazilian Catholics and French conservative writers, such as De Maistre, were very influential, while French priests and nuns provided schools for the children of the country's best families. Brazil, in a way, translated the French social, political and cultural cleavages into its own terms. For the influence of the French conservative Catholic thinkers in Brazil in a later period, cf. Francisco Iglesias, "Estudo sobre o Pensamento Reacionario," Revista Brasileira de Ciencias Sociais (Belo Horizonte), II, 2, 1962.

[14]For an account of the British influence through the spread of evolutionary Spencerism, cf. the chapter on "Progress and Spencer" in Graham, op. cit.; also Richard M. Morse, Manchester Economics and Paulista Sociology (Conference on the Crisis of Rapid Urban Development: Manchester and Sao Paulo, Stanford, April 1977, mimeo) for some insights on the differences between the two intellectual climates.

[15]For the surprising number of Brazilian students in Belgian technical schools, see Eddy Stols, "Les Etudiants Bresiliens en Belgique, 1817-1914," Revista de Historia (Sao Paulo), L, 100, vol. 2, year 25, 1974. No similar study on Brazilians in France seems to exist.

[16]On Brazilian positivism, see João Cruz Costa, Contribuicao a Histórica das Ideias Filosoficas no Brasil (Rio de Janeiro, ed. José Olímpio, 1956) and O Positivismo na Republica (São Paulo, Cia. Editoria Nacional, 1956); Ivan M. Lins, História do Positivismo no Brasil (São Paulo, Cia. Editora Nacional, 1964); and Antonio Paim, História das Idéias Filosóficas no Brasil (São Paulo: Ed. Grijalbo, 1974).

[17]Positivists were republicans in the sense that they were against a monarchy, but not in the sense that they supported the notions of multi-party systems, separations of powers, etc., which usually leads to an association between republicanism and democracy. Their Republic was meant to be an enlightened despotism with plebiscitarian support, to be run, of course, by the positivists themselves. For the more specific characteristics of positivism as a political ideology and praxis, in Brazil, see the pertinent sections on Julio de Castilhos in Joseph L. Love, Rio Grande do Sul and Brazilian Regionalism (Stanford, Stanford University Press, 1971).

[18]In this sense, positivism was very conservative. At the same time, they were probably the first in Brazilian history to talk about the economic and educational needs of the working sectors of the country, which was an important element in their overall concern with social modernization.

[19]A good sample of the positivistic way of thinking appears in a letter written by Benjamin Constant to his wife, probably the most important influential military and civilian positivist at the end of the Empire. Postivism, he says, is

> a new religion, but the most rational, the most philosophical, and the only one that follows from the laws to preside over human nature. It could not be the first religion, because its rise depended on knowledge of all laws of nature. This religion could not have emerged were it not for the admirable spirit of Auguste Comte, to whom it was given, by the vastness of his intelligence, to bridge the centuries which are still to come, capturing the wisdom of the sciences at their culmination, and giving us his scientific religion, the only and final religion of mankind. (Quoted in Ivan Lins, op. cit. The translation is mine.)

[20]The most comprehensive source for specific information on different scientific fields in nineteenth century Brazil are the articles published by Fernando de Azevedo in As Ciencias no Brasil (Sao Paulo: Ed. Melhoramentos, 1953 (?), 2 volumes). For the School of Mines in Ouro Preto, there is a monograph by José Murilo de Carvalho, A Escola de Minas de Outro Preto: Crepusculo de uma grande obra? (Rio de Janeiro, FINEP, 1977, manuscript).

[21]Summary descriptions of the activities of the naturalists in nineteenth century Brazil can be found in James W. Rowe,"Science and Politics in Brazil: Background of the 1967 Debate on Nuclear Energy Policy," in Kalman E. Silvert, ed., The Social Reality of Scientific Myth (New York: American Universities Field Staff, 1969) and Nancy Stepan, Beginnings of Brazilian Sciences: Oswaldo Cruz, Medical Research and Policy (New York: Science History Publications, 1976).

REFERENCES

[22]The references about the political transformations in Brazil at this time are too numerous to be listed here. For a personal interpretation, which stresses the significance of the cleavages between the São Paulo area and the country's political center, which remained in Rio, see Simon Schwartzman, São Paulo e o Estado Nacional (São Paulo: DIFEL, 1975).

[23]The Brazilian literature on the Bacteriological Institutes is extensive and some materials are also starting to appear in English. The most complete set of documents about the Oswaldo Cruz Institute (or Manguinhos, as it was first called) was put together by Edgar Cerqueira Falcão, Oswaldo Cruz, Monumenta Historica, 3 volumes (Sao Paulo, 1973), which contains in its second volume an historical narration by one of the Institute's scientists, Olympio na Fonseca Filho. The book by Nancy Stepan provides an historical analysis of its golden period, a comparison between the institutions of Rio and Sao Paulo, and an explanation for the reasons of Manguinhos' success.

[24]For an eyewitness description of the events in the biological sciences in São Paulo, see Mauricio Rocha e Silva, "Birth and Development of Experimental Science in Brazil," Interciencia, 1, 4, 1976.

[25]For the history of chemistry in Brazil, see R. Rheimboldt, "A Quimica no Brasil" in Fernando de Azevedo, As Ciencias no Brasil; and Simão Mathias, Cem Anos de Quimica no Brasil (São Paulo: Coleção da Revista de História, 1975).

[26]For the history of astronomy in Brazil, see Abraao de Morais, "A Astronomia no Brasil" in Fernando de Azevedo, As Ciencias no Brasil.

[27]This description is based on a written statement by Leio Gama, a Brazilian mathematician and former director of the National Conservatory, given to the project on the social history of Brazilian science.

[28]For a detailed account, see J. Costa Ribeiro, "A Fisica no Brasil," in Fernando de Azevedo, As Ciencias no Brasil, vol. 1, pp. 168-169. See also Amoroso Costa, Idéias Fundamentais da Matemática (São Paulo: Ed. Grijalbo, 1971) and the introductory essay by Antonio Paim, "O Neopositivismo no Brasil: Perido de Formação da Co-rente." See also note 16.

[29]For a detailed account of these developments, see Antonio Paim, A Ciencia na Universidade do Rio de Janeiro--1931/1945 (Rio de Janeiro: FINEP, project Historia Social das Ciencias no Brasil, forthcoming).

[30]Anisio Teixeira was the Secretary of Public Instruction of the Federal District (Rio de Janeiro) between 1932 and 1935. Fernando de Azevedo, another active member of the group, had been previously in charge of the educational reform in Rio, and after the 1932 insurrection became the Secretary for Education in the State of São Paulo.

REFERENCES

[31]For Francisco Campos' participation in the educational reform in Minas Gerais and his political career, see John D. Wirth, Minas Gerais in the Brazilian Federation, 1889-1937 (Stanford: Stanford University Press, 1977).

[32]The School of Philosophy of the "Universidade do Brasil" (now "Universidade do Rio de Janeiro"), established in 1938, was never meant to be a center for research, and did not have full-time teachers. An exception for that rule was the small group of physicists around Joaquim Costa Ribeiro, who, together with Bernard Gross, was responsible for the formation of an outstanding breed of scientists in the area of solid-state physics. The School of Medicine has had several important research lines, mostly around the Biophysics Institute.

[33]The reference is from a Manifesto which was published in 1933 supporting the creation of the School, which had the signatures of most of São Paulo's cultural and economic leaders at that time. The American influence is marked by the presence of several American professors throughout the years, as well as "books, and fellowships, which we received from public and private American institutions, such as the State Department, the Smithsonian Institution and the Rockefeller Foundation" (translated from Cyro Berlinck, A Escola de Sociologia e Politica de São Paulo (1933-1958) (São Paulo, 1958). Cooperation with the Smithsonian Institution was done through its former Institute of Social Anthropology and the work of Donald Pierson.

[34]A study of Brazilian scientific publications in international journals based on Who is Publishing in Science (WIPIS) lists 988 Brazilian authors in 1974, of which 234 were from the University of São Paulo, and 50 percent from the State of São Paulo (which also includes the University of Campinas, with 52 publications, and two schools of medicine and biology). The second largest institution in international publications was the Federal University of Rio de Janeiro, with 84, followed by the Federal University of Minas Gerais. (Campinas, however, is the highest on a per-capita basis, followed closely by the other Paulista establishments.) Internationally, Brazil ranked 29th in 1974, after Israel, Spain and Argentina (which was 28th), but ahead of Mexico (36th), Chile and Portugal (51st). In absolute terms, Brazilian production of scientific articles increased more than four-fold from 1967 to 1974; its share of the world's scientific production increased from 0.163 percent to 0.308 percent, which meant a modest advancement from the 32nd to the 29th ranking position. See Regina Lucia M. Morel and Carlos Medicis Morel, "Um Estudo Sobre a Produção Cientifica Brasileira Segundo os Dados do Institute for Scientific Information" (Rio de Janeiro, Ciencia da Informação, 1978), which also includes a discussion on the validity of this type of science indicators.

REFERENCES

[35]Cf. Frank D. McCann, Jr., The Brazilian-American Alliance, 1937-1945 (Princeton, New Jersey: Princeton University Press, 1973).

[36]Legal working privileges for diploma holders were established not only for the traditional professions--medical doctors, lawyers, engineers--but also for new professions like economists, statisticians, administrators, journalists, psychologists, and so on. Attempts to establish the legal privileges of sociologists, however, have failed so far.

[37]The Rockefeller Foundation has been present in Brazil since the twenties. Prior to the war, it worked mostly in the field of public health, not only in training Brazilian personnel but also working directly in the field. At the same time, it was responsible for the establishment of the first system of full-time teaching and research in Brazil, at the School of Medicine in Sao Paulo. During the war, a program of fellowships for Brazilian scientists was established, based on individual merit rather than on subject areas. This program benefitted scientists in physics, chemistry and genetics, with an emphasis on medicine and agricultural research.

[38]For a detailed study on the development of the physical sciences in Brazil, see Ricardo Guedes Ferreira Pinto, As Ciencias Fisicas no Brasil (M.A. Dissertation, Instituto Universitário de Pesquisas do Rio de Janeiro, 1978, mimeo).

[39]Besides the references in notes 4, 8 and 21, see Olympio Guilherme, O Brasil na Era Atomica (Rio de Janeiro: ed. Vitoria, 1957); Dagoberto Salles, Energia Atomica: um inquérito que abalou o Brasil (Rio de Janeiro: ed. Fulgor, 1958); Jose Leite Lopes, "A Física Nuclear No Brasil: os Primeiros 20 anos" in Homem, Ciencia e Tecnologia (Rio: ed. Paz e Terra, 1969); Hervásio G. Carvalho, "Pesquisa Básica e Aplicada no Desenvolvimento da Energia Nuclear" in Comissão de Ciencia e Tecnologia de Camara dos Deputados, Ciencia Tecnologia e Desenvolvimento (Brasilia, 1973); Jose Goldemberg, "A Crise de Energia e as opções do Brasil" in Interciencias, I, 1, 1976; and Rogério C. Cerqueira Leite, Energia Nuclear e Outras Mitologias (São Paulo, Livraria Duas Cidades, 1977).

[40]In a recent interview, the President of Nuclebras, the Brazilian agency for atomic energy, stated that "the Brazilian nuclear plan is basically industrial, and we see no reason to be concenred over this. On the contrary, it will allow us to carry out immediately useful projects, with clear-cut objectives and a fixed schedule." In an indirect reference to the criticism arising from the academic community, he then went on to say that "it would be reckless and even unrealistic to believe that Brazil, which does not have enough background in the organized research and development

of its own resources, even to solve essentially national problems, could lead the world in nuclear research in the field of fast-breed reactors, for example" (Paulo Nogueira Batista, interview published in O Globo, Rio de Janeiro, January 8, 1978).

[41]For an eye-witness overview of the SBPC in its first period, see Maurício Rocha e Silva, "Dez Anos pelo Progresso da Ciencia" in Revista Brasileira de Estudos Pedagogicos, 33(77): 221-234, 1960.

[42]The law that created FAPESP is based upon a paragraph of the State Constitution of Sao Paulo which was introduced, in 1946, by the well-known economic historican Caio Prado, Jr., at that time a representative of the Communist Party in the Constitutional Assembly. FAPESP receives one-half of one percent of all state tax revenues, and the resources are distributed by a scientific director, who is a member of São Paulo's scientific community and gets advice from expert advisers.

[43]In 1965 a joint commission was established between the United States Agency for International Development and the Brazilian Ministry of Education to make a global evaluation and recommendation about the reorganization of the Brazilian university system. The work of this Commission was important in the reorganization of the university system (with the creation of departments, central institutes and the political weakening of the professional schools) and the establishment of the graduate programs. It should be noted, however, that the University of Brasilia had been organized along similar lines several years before.

[44]Particularly hard-hit were the departments of Physics and social sciences of the University of São Paulo and the Manguinhos Institute in Rio de Janeiro. These forced retirements happened during the period of the military triumvirate that ruled the country after the death of President Costa e Silva, and responded to ideological prejudices as well as to personal feuds within these and other institutions.

[45]Karl Djerassi, and American chemist who was very important in a joint program in chemistry between the Brazilian National Research Council and the American National Academy of Sciences, stated in 1968 a blueprint for the creation of "centers of excellence" in developing countries, which certainly had its influence in Brazil. Cf. C. Djerassi, "A High Priority: Research Centers in Developing Nations" in Bulletin of the Atomic Scientists, 21, 1968. See also Manuel F. Moreira and B.K. Copeland, "International Cooperation in Science: Brazil-U.S. Chemistry Program" in Interciencias, I, 1976.

[46]See note 34 above.

REFERENCES

[47]Data on resource allocation for basic and applied science in developing countries are difficult to obtain. For an overview, see Michael J. Moravcsik, Science Development (Bloomington, Indiana: PASITAM, 1975), p. 108.

[48]The best example is probably CODETEC--A Company for Technology and Development--established recently by the University of Campinas to channel the research skills of its faculty to applied projects.

[49]A good example is COPPE--the coordination of graduate programs in engineering--which was established in the mid-sixties at the Federal University of Rio de Janeiro with resources from FUNTEC, and later FINEP. There is no doubt that COPPE became the best training course for engineers in the country. However, its impact in terms of new research and technology seems to have been minimal (its students would usually get a job in the labor market without ever finishing their master's dissertations). COPE is also a good example of the problems that can occur when a new, well-endowed and flexible program is superimposed over a traditional university system.

[50]For two recent examples, see the interviews given by Luis Hildebrando Pereira da Silva (a biologist who is the head of the Parasitology Department of the Institute Pasteur) to ISTOE (n. 55, January 11, 1978) and José Leite Lopes (a physicist who heads the division of High Energy Physics at the Centre de Recherches Nucleaires, Strasbourg) to Impact of Science in Society, 27, 3, 1977.