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# Looking for a place in the sun: science and technology in Latin America

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## Introduction

Politicians and their advisers are well aware that science and technology are essential to the social and economic development of their countries and to their citizens' well-being. Moreover, they are responsible for ensuring progress in those fields and thus for guaranteeing the allocation of resources necessary to achieve those goals. In Latin America, however, governments and business leaders often cite the importance of spending on research and development (R&D), but, as Gonzalo Rivas, head of the science and technology division at the Inter-American Development Bank (IDB) plainly stated, "They never put up the resources" [3]. The lack of support translates into official statistics that are in many cases misleading and an increasing lack of competitiveness in scientific and technological innovation.

A no doubt useful exercise would be to collect all the declarations formulated by members of different governments over a defined period of time and then compare them with the real-life conditions of scientific research, and R&D in general, in those countries. As Fabio Salamanca-Buentello, a Mexican physician working on the development and implementation of emerging technologies for the developing world and a member of the UNESCO Expert Committee on Nanoethics, pointed out, "there is a great lack of interest from our governments and our industries. And until that changes, scientists from the developing world will be always following the rules of the first world" [2].

According to Jesús Sebastián, who has extensively analyzed the economic, political, and social changes that have influenced the development of science and technology in Latin America, during the period between 1940 and 1960 this area experienced an industrialization that was focused on domestic market-based development and which relied on imported technology [8]. This should have been a starting point for real scientific and technological progress, but the opportunity was lost, in spite of the creation of research centers in a few productive sectors. Thus, the region continued its dependence on imported technology instead of promoting its own. This tendency acted like a brake, widening the gap with developed countries in matters of science and technology. Eventually, conditions started to change—although at different rates—throughout Latin America such that beginning in 1980 and continuing today there has been significant progress in the region. As a result, Latin America is currently working on important projects through international cooperation with partner countries, mainly in Europe and the United States. Although such gains have not been made in all Latin American countries, they have enabled some countries to overcome political and economical instabilities, and to emerge as advanced regions in various fields of science and technology. In others, significant improvements have been realized.

Throughout Latin America (as well as in Portugal and Spain), it has long been the case that during lean economic times cuts in public spending have been aimed first and foremost at culture, research, and science budgets. This is particularly true in countries in which a large part of the budget comes from the public sector, with very little originating from private industry. Moreover, as Jesús Sebastián remarked, in a large number of countries eager to be involved in innovation systems, public investment has come from loans from the Inter-American Development Bank and the World Bank [8]. However, most of these countries are neither scientifically nor technologically prepared to develop innovation systems. It would be akin to building a house starting from the roof.

## Achievements of today and challenges of tomorrow

The positive correlation between increases in the financial resources devoted to R&D and scientific production is well-established, as evidenced by the number of articles published in scientific journals, patents awarded, brain gain, international cooperation agreements, students sent abroad to com-

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plete their training and careers in foreign laboratories, as well as public interest in scientific matters. Francisco Ayala [1] confirmed the close relationship between a country's R&D investments and its scientific production. Taking Spain as an example, he analyzed the data published by UNESCO and the Institute for Scientific Information (ISI). At the time of the study, which covered the period 1982–1992, Spanish investment in R&D rose from 0.48 to 0.90% of gross domestic product (GDP). Consequently, Spanish scientific production increased from less than 1% in 1984 to 2% in 1992 (during this period, the number of scientific articles published increased from 3900 to 14,000.)

During the past 10 years, the percentage of GDP invested in R&D in Latin America has increased, from an average of 0.45% in 1998 to 0.68% in 2007 (Table 1). This is a relative figure due to the large differences among different Latin American countries. Brazil, for instance, is the only country in the region whose investment in R&D exceeds 1% of its GDP. The average for the European Union (EU-27) is 1.83%, but it is also necessary to consider the relative investment by each country. In Spain, for example, R&D investment is approximately 1.27% of GDP, significantly lower than the EU average.

In our field, the training of professionals in basic and applied microbiology requires study in areas that are constantly evolving and expanding, accompanied by rapidly improving technological capabilities. As in most of the "hard" sciences, continuing education is essential for researchers to be able take advantage of current knowledge and methodologies. One of the ongoing challenges of microbiology is to provide adequate training for the next generation of microbiologists. At the same time, there is an urgent need to educate the public and members of the government regarding the crucial importance of science in improving the health and prosperity of the country and its citizens.

Currently, universities in industrialized countries offer numerous basic and postdoctoral programs in microbiology. In April 2009, Spain joined many Latin American countries by offering a university degree in Microbiology, in the form of a Bachelor's program in Microbiology (four years, eight semesters), at the Autonomous University of Barcelona. In its first year, there were 681 applicants. The number of students finally accepted was 63. This level of interest is further proof that Microbiology is a springboard for obtaining a wealth of knowledge with applications in areas as diverse as agriculture, health, environment, biotechnology, and engineering [5]. Today, more than ever, efforts must be made to guarantee the continuity of such programs and to prevent regional economic trends from impeding education and research.

**Table 1.** Indicators of science and technology development in Latin America 2007 [5]

| Country | Publications* | %GDP in R&D** | Students sent abroad for training completion [2] |
|---|---|---|---|
| Brazil | 23,109 | 1.11 | 14,828 |
| Mexico | 8501 | 0.46 | 21,363 |
| Argentina | 6479 | 0.51 | 8326 |
| Chile | 3559 | 0.79 | 6745 |
| Venezuela | 1261 | nf | 9101 |
| Colombia | 1239 | 0.16 | 15,981 |
| Cuba | 748 | 0.44 | 1322 |
| Uruguay | 518 | 0.44 | 1905 |
| Peru | 593 | 0.15 | 8252 |
| Costa Rica | 398 | 0.32 | 1434 |
| Ecuador | 287 | 0.15 | 5337 |
| Panama | 369 | 0.20 | 1755 |
| Bolivia | 201 | 0.26 | 2813 |
| Guatemala | 101 | 0.06 | 2093 |
| Paraguay | 57 | 0.09 | 1577 |
| Nicaragua | 48 | 0.05 | 1785 |
| El Salvador | 25 | 0.09 | 1948 |
| Honduras | 31 | 0.06 | 2046 |

* Number of publications from more than 6100 journals covering the life sciences, environment, technology, and medicine. Database managed by ISI. Source: Estado de la ciencia 2009.

** Data for Bolivia and Nicaragua (2002); Peru and Honduras (2004); Paraguay (2005).

nf, not found.

## Looking back (and ahead) with pride

The contributions of Latin American scientists to the advancement of science, and, specifically, to the field of microbiology, have been broadly recognized and promoted by the Spanish Society for Microbiology, including in its publications *Microbiología SEM–International Microbiology*. Between 1996 and 1998, the journal published several editorials under the heading *Science in Latin America*. This recognition has continued with the more recent publication in *International Microbiology* of short biographies of important Latin American microbiologists, accompanied by photographs of those scientists on the back covers of the journal (Table 2). Historically, a large number of infections illnesses were successfully combated following the discovery of their

**Table 2.** Classical Latin American and Spanish microbiologists presented on the back covers of *International Microbiology* since 2004

| Scientist's name/journal issue | Country | Field/Main contributions |
|---|---|---|
| Jaime Ferrán (1849-1929)<br>Int Microbiol 7(1,2) 2004 | Spain | Recognized for his work on active immunization against cholera in humans. Between 1881 and 1885, he immunized 50,000 people and later advocated similar preventive measures for other infections. |
| Oswaldo G. Cruz (1872-1917)<br>Int Microbiol 7(3,4) 2004 | Brazil | Father of Brazilian sanitation. Fighter against yellow fever, which he eradicated from Rio de Janeiro and Belem do Pará. He introduced preventive disease measures in Brazil. |
| Juan Noé Crevani (1877-1947)<br>Int Microbiol 8(1,2) 2005 | Chile | Worked on several infectious diseases, including malaria, which was later eradicated in Chile by his collaborators. |
| Eugenio Espejo (1747-1795)<br>Int Microbiol 8(3,4) 2005 | Ecuador | One of the fathers of bacteriology. He realized the role of air as a vector of living beings causing diseases and advanced the idea that specific agents are involved in the process of fermentation. |
| Alfonso L. Herrera (1868-1942)<br>Int Microbiol 9(1,2) 2006 | Mexico | Developed the hypothesis of plasmogeny, which led to a better understanding of both the uniformity of nature and the origin of life. His books were considered the best Darwinian works of that time in Mexico. |
| Clodomiro Picado (1887-1944)<br>Int Microbiol 9(3,4) 2006 | Costa Rica | Pioneer in toxicology. He developed anti-venom antisera, and his book on this topic brought him international recognition. His experiments in 1915 and 1927 demonstrated the inhibitory action of *Penicillium*. |
| Francisco X. Balmis (1753-1819)<br>Int Microbiol 10(1,2) 2007 | Spain | Led the first global vaccination campaign against smallpox, in 1830, as a physician on the Real Expedición Filantrópica de la Vacuna on board the ship María Pita. The mission enabled distribution of the vaccine into all overseas Spanish territories. |
| Louis D. Beauperthuy (1807-1871)<br>Int Microbiol 10(3,4) 2007 | Venezuela | Carried out detailed observations on the spread and treatment of many diseases. He was the first to describe scabies as a parasitic infection. |
| Carlos J. Finlay (1833–1915)<br>Int Microb 11(1,2) 2008 | Cuba | He discovered the vector of yellow fever and, among other advances, contributed to the decrease in newborn mortality by implementing a new sterile process. |
| José de Arechavaleta (1838–1912)<br>Int Microb 11(3,4) 2008 | Uruguay | Founded the Laboratory of Bacteriology, from which the Public Health Institute originated. In 1886, he and his colleague Pedro Hormaeche wrote a leaflet describing the *Virgula* bacillum and providing instructions regarding methods to prevent cholera. |
| Carlos G. Malbrán (1862–1940)<br>Int Microb 12(1,2) 2009 | Argentina | Promoted public health in Argentina. He was the first public health surveyor appointed by the municipality of Buenos Aires. |
| Daniel Alcides Carrión (1857–1885)<br>Int Microb 12(3,4) 2009 | Peru | Demonstrated that the Oroya fever and "Peruvian wart" were two different clinical manifestations of an infection known today as "Carrion's disease" (a bartonellosis). |
| Rodolfo Robles Valverde (1878–1939)<br>Int Microb 13(1,2) 2010 | Guatemala | Physician who identified the parasitic nematode *Onchocerca calculus* as the causal agent of onchocerciasis, and also discovered the black fly as the disease vector. |
| Carlos Chagas (1879–1934)<br>Int Microb 13(3,4) 2010 | Brazil | Discover of American trypanosomiasis, known as Chagas disease, caused by *Trypanosoma cruzi*. |

causal agent by researchers in Latin America, where many of the diseases were endemic. At the same time, the pioneering work of those scientists (many of whom were physicians) provided scientists elsewhere with the insight necessary to find the cause of many other infectious diseases.

Over 80% of the world's population lives in developing countries, but the percentage of researchers working in these countries is only about 30%. According to a report from the Network on Science and Technology Indicators (RICYT) [6], Latin American countries account for approximately 2% of the world's investment in R&D, followed by Africa and Oceania (0.3%). This is far behind the United States (39%), Europe (31%), and Asia (26%). Nevertheless, it is important to recognize that, in spite of scant funds, the quality of science developed in Latin American research centers has clearly improved in recent years. The number of scientific publications, one of the main indicators of the status of science in a country, has grown more than in any other region of the world—far more than would be expected given these countries' investment in R&D. Perhaps not surprisingly, Brazil heads this list, with over 31,000 publications in the Science Citation Index (representing a global percentage of 2.32%), according to data for 2008 from the RICYT. It is followed by Mexico (0.64%), Argentina (0.49%), Chile (0.27%), and Venezuela (0.01). A complete and more detailed list is available on the RICYT's web site.

On average, scientific journals publish less than 10% of the manuscripts submitted. In some cases, this is interpreted as proof of their power of decision regarding the course of science and their favoring of established groups and centers, to the detriment of those of more modest backgrounds. This may be true for the journals managed by large editorial companies or those which have reached international prominence. But it is not necessarily the case of journals forced to maintain the quality of their contents with only minimal financial support and thus with a lower profile.

*International Microbiology*, for example, receives a steady stream of papers addressing a wide range of topics in basic and applied microbiology. Many of these papers are authored by colleagues from Latin America and, after passing the journal's compulsory peer review process, are accepted for publication (Table 3).

Salamanca-Buentello reported that only 15% of all the scientific publications in the world come from developing countries. The power to change that fact lies in the hands of those countries' governments, by increasing general interest in and public support of science and technology. In addition, active participation and investment in R&D by private industries is critical. In 2006, *The Lancet* published a paper authored by 11 Latin American scientists, led by Chilean researcher Miguel O'Ryan. The work described in that report, a vaccine against rotavirus, the most common cause of diarrhea in children, was considered by the prestigious journal to be the best medical research of the year. O'Ryan, who directs the Microbiology and Mycology program at the Biomedical Sciences Institute of the University of Chile, pointed out that support received by the group from private companies was a key factor in the successful development of the vaccine [2].

Also of interest is the number of Latin American students who choose to go abroad to complete their training. With the

**Table 3.** Articles from Latin America[a] published in International Microbiology from 2000 to 2010

| Year | Spain | Rest of Europe | Latin America | USA & Canada | Other countries |
|---|---|---|---|---|---|
| 2000 | 25 | 7 | 3 | 6 | – |
| 2001 | 18 | 6 | 2 | 5 | 3 |
| 2002 | 21 | 3 | 2 | 6 | 3 |
| 2003 | 19 | 6 | 9 | 5 | 3 |
| 2004 | 24 | 7 | 5 | 2 | 2 |
| 2005 | 27 | 4 | 5 | 2 | 1 |
| 2006 | 22 | 7 | 4 | 6 | 1 |
| 2007 | 28 | 1 | 4 | 4 | 1 |
| 2008 | 23 | 7 | 6 | – | – |
| 2009 | 18 | 6 | 3 | 1 | 1 |
| 2010[b] | 11 | 2 | 1 | 1 | – |

[a] Based on the affiliation of the corresponding author.
[b] Until the present issue, September 2010.

exception of students in Cuba and Paraguay, the first country chosen by young researchers is the United States, followed distantly by Spain and other European or Latin American countries. This may explain an observation made by Mario Albornoz, an expert in scientific and technological policies and current coordinator of the RICYT. He pointed out that the performance of Latin American scientists has been greater than the emphasis placed on science and the technology by public policies. Indeed, worldwide, Latin America has seen the highest increase in the number of researchers and technicians. The figure of 259,000 (full-time employment) in 2007 duplicates that of the previous decade [6].

## Towards the future

The field of microbiology has experienced rapid and seemingly uninterrupted progress over the past decade, continuing the pace set at the end of the last century. Despite marked differences in research capabilities among countries, the benefits reaped from that progress have further stimulated the efforts of researchers and the interest of the societies they belong to.

The strength of a scientific field within a particular country depends on many factors, one of which is the critical mass of researchers and the quality of the training they receive, which is typically completed with a period of postdoctoral training, often in a prestigious center abroad. Past and recent initiatives such as the RICYT, the Ibero-American Area for Knowledge (EIC) project, and well-attended meetings and congresses are in many ways representative of a region's scientific status. More importantly, perhaps, activities such as these encourage exchange and communication between researchers of different origins. Thus, Latin America as a whole can take pride in the contributions of its researchers to the advancement of science in their own and in other countries in which they work. Another contribution of Latin America to the development of microbiology is the enormous biological diversity of its ecosystems, which offer innumerable study possibilities and attract researchers from around the globe.

Without a doubt, and without losing sight of the long road ahead, Latin American scientific output has made significant gains towards finding its place in the sun, in terms of achieving full equality with respect to resources, opportunities, and collaboration with the international scientific community. However, it is critical that public and private institutions take the lead in recognizing science and scientists, as innovation and R&D offer an important way for a society to overcome its economic difficulties, while guaranteeing its future and its welfare. The scientific and technological applications that derive from research have an enormous impact on a society's quality of life, its industries, and its economy. That is why it is crucial for Latin America to expand its investment in the development of science.

## The 20th ALAM meeting: Montevideo, September 2010

Montevideo, the capital of Uruguay, will host the 20th Latin American Congress of Microbiology [http://www.alam2010.org.uy] on 27–30 September, 2010. The meeting has been organized by the Uruguayan Society for Microbiology on behalf of the Latin American Association for Microbiology (ALAM). Uruguay succeeds Ecuador, which in October 2008 held the ALAM Congress, chaired by Maria Fernanda Espinoza, president of the Ecuadorian Society for Microbiology. The Ecuador meeting attracted over 500 microbiologists from 18 countries, with more than 20 prestigious researchers from Argentina, Belgium, Canada, Chile, Colombia, Cuba, Paraguay, Peru, Spain, the UK, Uruguay, the USA, and Venezuela actively participating in the event. The meeting consisted of an exhaustive program that provided up-to-date information on a multitude of topics, including those in the fields of emerging and re-emerging diseases, antibiotic resistance, the diagnosis of infectious diseases, veterinary microbiology, environmental microbiology, industrial microbiology, and an overview of the state of the art of Microbiology in Latin America [9].

Matilde Soubes will chair the Uruguay Congress, whose academic program will be conducted by over 40 renowned researchers from Latin America, the USA, and Europe (France, Holland, Portugal, Spain, and the UK). As was true for its predecessors, this Congress' goal is to generate an atmosphere allowing the exchange of knowledge and experience amongst microbiologists from Latin America and elsewhere. The information shared among microbiologists is not only of academic interest, but has wider, more long-term benefits for the general public, with respect to public health surveillance, the control of food safety, and the development of new strategies for innovation in microbiological research, among others.

The ALAM is made up of national microbiology societies from Latin American countries [4]. It facilitates cooperation among microbiologists, enhancing the practice and evolution of this discipline thorough research and teaching. The continuity of the ALAM's congresses is of great importance as they offer a unique opportunity in Latin America to promote scientific exchange and communication among microbiologists at all levels of the profession and to attract the interest and curiosity of young people, encouraging their participa-

tion in this discipline. The Uruguayan Society for Microbiology, as the chair of the 20th ALAM meeting, will once again bring together people who have dedicated themselves professionally to the many different fields of microbiology. It is through the organization of scientific activities such as those hosted by the ALAM, in addition to conferences, seminars, workshops, and other such actions, that the continued growth and development of our profession are insured.

## Microbiology in Latin America

To draw the line between the past and the future, we translate here the words written, more than a decade ago, by renowned microbiologist, colleague, and friend, Moselio Schaechter, together with Cristián Orrego [7].

"There have been internationally important discoveries made in Latin America, and the most well-known correspond to the area of medical microbiology. It is easy to remember famous eponyms and figures in names such as Chagas disease, *Trypanosoma cruzi*, or *Rochalimaea quintana*, adorning microbiological lexicon. Latin American microbiologists have become part of the lore of our discipline, some for their personal sacrifices, such as the Peruvian Daniel Carrión, others for the force of their scientific beliefs, such as the Cuban Carlos Finlay. This tradition goes back to the origin of our science, when some Latin Americans traveled to Europe with the desire of obtaining the necessary knowledge in pioneer laboratories, especially those of Pasteur and his disciples.

The contributions of scientists in this part of the world have continued to this day, thus extending the range of discoveries, from the essential foundations to the application. Renowned institutions, especially in some countries, have achieved very significant levels of productivity and well deserved prestige. Brazil, Argentina, Mexico, Chile, and Venezuela are among the countries with a longer tradition in research and have front-line institutions. Others, fortunately, are now uniting their efforts."

In today's world, which is undergoing an irreversible process of globalization, the integration of efforts between countries is the logical approach to solving problems that affect the entire planet. The aforementioned initiatives and many others are an opportunity to join efforts and to look ahead, not alone, but in cooperation with the world's scientific community—men and women who approach their work with both their brains and their hearts.

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