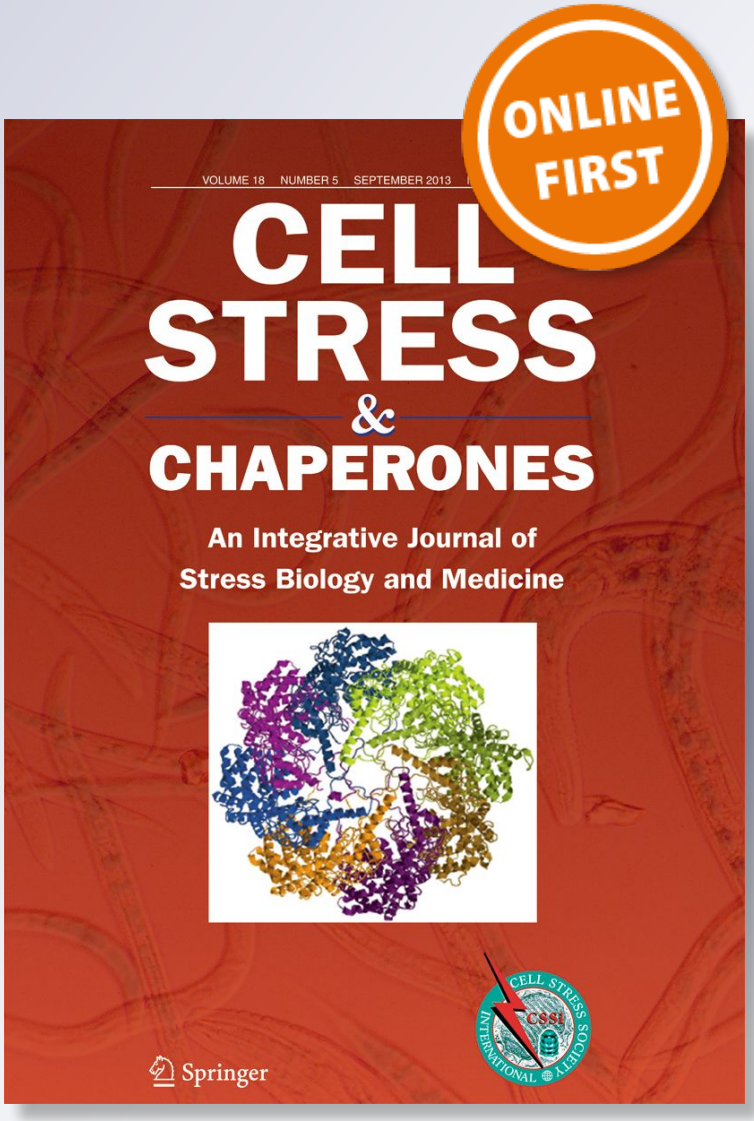
The reality of scientific research in Latin America; an insider's perspective

Daniel R. Ciocca & Gabriela Delgado

Cell Stress and Chaperones
A Comprehensive Journal of Stress Biology and Medicine

ISSN 1355-8145

Cell Stress and Chaperones
DOI 10.1007/s12192-017-0815-8



Springer

Cell Stress and Chaperones
DOI 10.1007/s12192-017-0815-8

ORIGINAL PAPER

The reality of scientific research in Latin America; an insider's perspective

Daniel R. Ciocca[1] · **Gabriela Delgado**[2]

Abstract There is tremendous disparity in scientific productivity among nations, particularly in Latin America. At first sight, this could be linked to the relative economic health of the different countries of the region, but even large and relatively rich Latin American countries do not produce a good level of science. Although Latin America has increased the number of its scientists and research institutions in recent years, the gap between developed countries and Latin American countries is startling. The prime importance of science and technology to the development of a nation remains unacknowledged. The major factors contributing to low scientific productivity are the limited access to grant opportunities, inadequate budgets, substandard levels of laboratory infrastructure and equipment, the high cost and limited supply of reagents, and inadequate salaries and personal insecurity of scientists. The political and economic instability in several Latin America countries results in a lack of long-term goals that are essential to the development of science. In Latin America, science is not an engine of the economy. Most equipment and supplies are imported, and national industries are not given the incentives to produce these goods at home. It is a pity that Latin American society has become accustomed to expect new science and technological developments to come from developed countries rather than from their own scientists. In this article, we present a critical view of the Latin American investigator's daily life, particularly in the area of biomedicine. Too many bright young minds continue to leave Latin America for developed countries, where they are very successful. However, we still have many enthusiastic young graduates who want to make a career in science and contribute to society. Governments need to improve the status of science for the sake of these young graduates who represent the intellectual and economic future of their countries.

Keywords Latin America · Science · Technology · Grants · Publications · Research

✉ Daniel R. Ciocca
dciocca@mendoza-conicet.gob.ar

Gabriela Delgado
lgdelgadom@unal.edu.co

[1] Oncology Laboratory, Institute of Experimental Medicine and Biology, CONICET, CCT, 5500 Mendoza, Argentina

[2] Immunotoxicology Research Group, Pharmacy Department, Universidad Nacional de Colombia, Carrera 30 No. 45-03, Edificio 450, Bogotá, Colombia

Social and economic disparities in Latin America

The day-to-day life of Latin Americans is greatly affected by the political composition of their ruling governments. Policies implemented by parties that come and go have a great impact on the economy; health care; and education; and not surprisingly, scientific activity. Latin America is made up of many countries with different histories, different economies, and different political situations (Schneider 2014). However, even relatively stable countries like Chile and Uruguay (currently politically and economically healthy) have suffered in recent history from dictatorial, autocratic, and/or populist governments (Puhle 1987; Arenas 2006; Donghi 2013). None of these countries give enough priority to scientific and technological developments (Schneider 2014), which has a tremendous impact on the life of their citizens. In some countries, the existence of a well-equipped research laboratory depends on whether the investigator shares the ideology of the ruling government. Moreover, Latin American countries have the most unequal income distribution in the world (United Nations

Published online: 05 June 2017

Commission on Science and Technology for Development 2013) which results in research inequalities across the region (Van Noorden 2014). The macro-economy reflected in the gross domestic product (GDP) of nations like Brazil, Mexico, and Argentina is far higher than of other Latin American countries (World Development Indicators), but these countries are coping with the same problems as others in the region. Brazil is fighting political and economic instability, corruption, crime, and narco-traffickers and is slowly emerging out of its recession; Mexico has high levels of corruption, crime, and narco-trafficking; and Argentina has a very high level of inflation and is fighting corruption, crime, and narco-traffickers. Colombia has been at war with guerrillas and narco-traffickers for years, Venezuela is suffering from a decaying economy after years of populism, Peruvians are clamoring for less discrimination and inequality, Chileans are demanding better educational options and lower inequality, and Cubans are still trying to identify and solve their own problems. All this creates stress for ordinary citizens and scientists alike and makes us pessimistic about the economic forecast for Latin America (Cottani and Oliveros-Rosen 2016).

Importance of science

The contributions of science to society are obvious in many discoveries in medicine (e.g., antibiotics) and in the development of technologies (e.g., computers). For this reason, developed countries spend a large proportion of their annual budgets on research. Unfortunately, this paradigm has not been adopted by Latin American countries where research is still a minor activity performed by an "elite" class of individuals. Thus, countries with a weak research tradition are reliant on nations with a robust research culture and remain mainly providers of raw materials. Moreover, problems unique to a particular developing country will remain ignored by the global scientific community until they too are affected, as was clearly shown in the case of the Ebola epidemic (Omoleke et al. 2016). Latin American scientists have been very successful in global scientific work; several Latin American investigators have been Nobel Laureates in the Natural Sciences (LaRosa and Mejia 2015). The low scientific productivity in Latin America is not the result of a lack of creativity but is rather the product of a negative environment created by the leadership of each nation. The allocation of resources for research in Latin America is in great disproportion with that in developed countries (Table 1).

We acknowledge some progress in the sciences however; Brazil, Mexico, and Argentina have been leading in several parameters of science in Latin America (Albornoz 2002). Mexico increased its expenditures in research and development between 2012 and 2016 (Sánchez 2016). But, all Latin American countries are still functioning far below developed countries (Ruiz 2000; Piñón 2003; Kuramoto 2013). It is clear that in Bolivia, El Salvador, Guatemala, Paraguay, and Peru, the resources assigned for research and development (by both public funds and by private businesses) are not priorities for their governments (Table 1). In addition, Latin American countries are not using scientific developments to solve their problems in health care, education, poverty, and the unequal distribution of wealth. According to the Chilean scientist P. Astudillo, a scientific policy was adopted in Chile that reduced research to its economic dimension only and which has proved a failure (Astudillo 2016). This author also emphasizes that in today's society, decision-making in practically all areas must be accompanied by scientific knowledge (Astudillo 2016). In a global world, scientific and technological development will generate jobs of both high quality and high human capital and those nations that do not keep pace will suffer the greatest loss (Schuster 2017).

Research funding in Latin America

Although Latin American institutions have high expectations for their investigators and require them to publish in high impact journals (Thomaz and Mormul 2014), the financial support for research is inadequate to meet these high standards. Most grants in Latin America are provided by governmental institutions and are insufficient for the needs of a competitive research enterprise. A typical governmental grant for a research group or laboratory in Latin America is in the order of $5,000 to $40,000 per year, which is well below typical grants provided by well-developed countries.

Unlike in the USA where science is truly an engine of the economy, private industries in Latin America are in general reluctant to invest in scientific development. Latin America and the Caribbean countries invest less in research than other developed and emerging countries, and the participation of private companies is very limited (Lemarchand 2010, United Nations Commission on Science and Technology for Development 2013). There are some government programs designed to encourage private companies to invest in scientific and technological developments, such as the FONTAR program in Argentina that assigned almost $50 million to develop manufacturing of computerized machinery and equipment. However, these possibilities are limited and are basically driven by the government (Erben 2016).

A major problem in Latin America is a lack of clear rules for the distribution of research funding, which is sometimes distributed based on political alliances and aggravated by economic instability, resulting in a negative impact on the development of innovative technologies. Moreover, government taxes are high without a corresponding investment in resources. Most reagents and equipment have to be imported

Table 1 Funds assigned for research and other data in Latin America

Country	Population[a]	Inflation[b]	UR[c]	GDP (R + D)[d]	Researchers[e]
Argentina	41.45 M	28.3 (2014)	7.3 (2014)	0.58 (2017)	1121 (2010)
Brazil	200.4	9–11 (2015)	8.5 (2015)	1.24 (2013)	698 (2010)
Bolivia	11	3–4 (2015)	4 (2015)	0.16 (2009)	166 (2010)
Chile	17.62	4.4 (2015)	6.3 (2015)	0.36 (2012)	320 (2012)
Colombia	48.32	5–6 (2015)	8.9 (2015)	0.23 (2013)	193 (2010)
Costa Rica	4.87	−1 (2015)	9.7 (2014)	0.47 (2011)	1233 (2010)
Cuba	11.27	6 (2013)	NA	0.47 (2013)	NA
Ecuador	15.74	4 (2015)	5.4 (2015)	0.34 (2011)	141 (2010)
El Salvador	6.34	1 (2015)	7 (2014)	0.03 (2012)	NA
Guatemala	15.47	2–3 (2015)	NA	0.04 (2012)	25 (2010)
México	122.3	2.7 (2015)	4 (2015)	0.50 (2013)	312 (2010)
Panamá	3.86	0.3 (2015)	5.1 (2015)	0.18 (2011)	NA (2010)
Paraguay	6.8	3.1 (2015)	5.8 (2015)	0.09 (2012)	NA
Peru	30.9	3–4 (2015)	6.5 (2015)	0.15 (2014)	NA
Puerto Rico	3.54	−1 (2015)	14 (2014)	0.44 (2013)	NA
Trinidad and Tobago	1.34	1–4 (2015)	3.4 (2015)	0.05 (2012)	NA
Uruguay	3.40	8–9 (2015)	7.5 (2015)	0.32 (2013)	549 (2010)
Venezuela	30	140 (2015)	6.8 (2015)	0.2–0.5 (2006)	200 (2010)
Developed countries (added for comparative purposes)					
USA	316	3.29 (2015)	5.5 (2015)	2.73 (2013)	3867 (2010)
China	1357	1.44 (2015)	3.1 (2016)	2.01 (2013)	903 (2010)
Japan	127	0,80 (2015)	4.1 (2015)	3.47 (2013)	5153 (2010)

Some countries are not mentioned because we were unable to locate their GDP for R + D

NA not available

[a] Population for the year 2013, expressed in millions (M)

[b,c] Annual inflation and UR: unemployment rate from http://www.focus-economics.com/regions/latin-america

[d] Percentage of the GDP assigned to Research and Development. From http://datos.bancomundial.org/indicador/GB.XPD.RSDV.GD.ZS

[e] Per million people. Data from: http://data.worldbank.org/indicator/SP.POP.SCIE.RD.P6

from other countries. When asked to provide goods for research, Latin American industries argue that scientists prefer to purchase products from recognized international companies and that they cannot compete with foreign companies.

The contribution to science by universities differs from country to country. Argentina mandates that professors combine their teaching with high-impact scientific work; however, the government and university support for academic research is very limited (Dallanegra Pedraza 2004). In Colombia and Brazil, support for research activities is significant at private universities. In Colombia, public universities invest even more in research and development than private universities do. In Chile, universities play a significant role, with about 80% of the total number of researchers having a doctoral degree (Quiroz 2016). In Cuba, despite the existence of a set of laws and resolutions to organize science financing, these resources are often not well used due to the poor organization of this financing system (Benet Rodríguez et al. 2010).

In summary, economic resources assigned for research grants in Latin America fall short of what is needed. The UNESCO Science Report (UNESCO 2015) emphasized that most Latin American countries have not used their valuable exports in recent years to stimulate scientific and technological competitiveness, such as in the development of pharmaceutical and/or equipment industries to avoid the high cost of medical supplies.

Purchasing products for scientific research: the economic drain

The international scientific community is probably unaware of the difficulties Latin American researchers face daily to acquire the reagents and equipment necessary for their work. Prices are disproportionately high compared with those in developed countries. Two factors drive up the cost of scientific

reagents and equipment in Latin America. The import of scientific supplies is not excluded from a heavy tax intended to protect national products and which does not apply to research products that are locally produced. Indeed, many Latin American countries do not support free trade agreements with the USA, and research goods are considerably more expensive. In addition, customs bureaucracy is responsible for the delay of merchandise delivery which affects the quality of the products. Finally, there is no free competition among reagent suppliers, which form a monopoly directed at speculation. Most Latin American countries concentrate their resources and researchers in large cities, placing smaller cities at a disadvantage for the distribution of reagents and supplies and making collaboration among scientists more difficult. In a relatively small city (1 million), when one research laboratory has a broken flow cytometer, there may be no replacement in the same city.

The economic and social burden of Latin American scientists

In many Latin America countries, scientists do not have a salary in accordance with their education, knowledge, and contribution to society. Scientists' salaries are markedly lower than those of judges and elected officials (Table 2). The low purchasing power of scientists makes it difficult to buy a home and support the education of their children. In addition, increased crime has forced scientists to live in gated communities, and the deterioration of public education has forced them to send their children to private schools. Scientists expend a large proportion of their salaries on these important items. Many young graduates see the scientific environment as too restricted, too competitive, and too poorly funded to provide a certain future in research institutions. Because a career in science is poorly paid, most medical doctors are better off pursuing a clinical practice rather than participating in research, even part time. Indeed, there are fewer than 10% of medical doctors in the Commission of Medical Sciences in the Argentine National Research Council (CONICET).

Nowadays, a publication fee of $3400–5000 applies to high-impact factor journals; these journals offer publication fee discounts for papers whose corresponding authors are based in HINARI countries (the world's lowest-income countries as defined by the World Bank): Guatemala, Honduras, and Nicaragua are in the free-access group while Argentina, Bolivia, and El Salvador are in the low-cost access. Therefore, many Latin American scientists prefer to publish their scientific discoveries in journals that do not charge for publication costs since it is very difficult to pay page charges from their modest grants. These journals are the ones with lower impact factors, which may make Latin American science seem second rate. In addition, most governments or academic institutions have not signed agreements for access to open-access articles, creating difficulties for Latin American scientists to obtain high-impact research articles; the cost of subscriptions is a serious problem for Latin American institutions with very limited budgets.

Bureaucracy and other problems

At first sight, the number of research institutions, programs, commissions, and other research-related entities in Latin America is overwhelming (Lemarchand 2010). However, most of these institutions are plagued with bureaucracy. For example, the Ministry of Science, Technology, and Productive Innovation of Argentina has 19 independent agencies, programs, foundations, and offices, of which CONICET is one. The administrative structure is at odds with the reduced grant support, and therefore, it is not surprising that in CONICET, almost 95% of the resources are destined to pay wages. It is clear that science has not been a priority for Latin American governments; in 2014, Argentina spent about $150 million dollars on the program "Soccer for All" (a program that supported the free televising of soccer games), a budget similar to that of the Ministry of Science, Technology, and Productive Innovation (this soccer program has since been discontinued).

The lack of vision that science and technology are of prime importance to the development of a nation is a chronic problem. Latin American countries are still very far from other countries in scientific performance. For the period 2000–2015, Brazil ranked 14th, while Mexico ranked 30th, whereas Argentina, Chile, Colombia, Venezuela, Cuba, Peru, Uruguay, Costa Rica, Ecuador, and Panama appeared even lower in the list (in that order) (Zanotto et al. 2016). This report stressed the importance of scientific collaboration, which is still far from what it should be. The low number of patents is another parameter to be considered (Kreimer 2016). The statement that Chile needs long and medium-term (public) policies to establish clear goals bringing together its political class, citizens, entrepreneurs, and scientists (Quiroz 2016) is applicable to most Latin American countries.

Latin American scientists have to be at an international level to win grants and promotions in the scientific careers and have to compete on research topics of international interest. It could be argued that science in Latin America should be directed to solve specific local problems, such as the impact of Dengue and Zika infections, and Chagas disease, or to find cheaper diagnostic methods and new regional phytochemicals that could be used to treat diseases. However, grants to support applied research are not easy to obtain because national priorities are unfocused and because it is difficult to publish the results in high-impact journals, which is against the interests of the investigators, thus creating a vicious circle. The World Health Organization has stressed the importance of research

Table 2 Data comparing salaries and prices of apartments and cars in Latin America

Country	Researcher	Judge	Senator	Professor	Apartment	Car
Argentina	1200–3000	10,000	6000	2000	≅180,000	≅24,000
Brazil	1700–4000	10,000	8000	4000	200,000	≅18,500
Chile	2000–5000	7000	12,000	5000	≅150,000	≅14,000
Colombia	3000–7000	5000	10,000	3000–8000	≅200,000	≅19,000
Mexico	2200–3500	6300	6700	3600	≅190,000	≅15,500
Uruguay	2600–3500	4300	3400	3500	≅190,000	≅22,000

The salary in USD per month, in the case of researches considering the first position (young investigator) and the last position (about 30 years) in the main research institutions. These data have been provided by researchers from the different countries and the salaries are considering the basic + additional (pocket money). Judge: federal, with 30 years. Senator: national. Professor: full time in a National University. Apartment: price of a two bedrooms apartment in the capital of the country in a good location. Car: price of a brand new, medium-sized car (taken as example Renault Duster)

into local problems to improve health systems, priorities, and research goals for low- and middle-income countries (Xue et al. 2014).

The problem of brain drain

Latin America has a long history of "brain drain" while developed countries have the advantage of "brain gain." In Chile, many young researchers and post-doctoral students find it difficult to get a foothold in the scientific system and only obtain precarious research jobs (Astudillo 2016). Central to this problem is the question: Are there enough research institutions to hire and retain scientists in their home countries? We mentioned earlier that the number of research institutions in Latin America is surprisingly large (Lemarchand 2010). However, the facilities are often inadequate; laboratories are not up to date; grants are relatively low; salaries are not at an international level; and scientists, like other citizens, feel personally insecure. In Argentina, the number of people with a doctoral education has increased noticeably in recent years, but only 50% have been absorbed into the national scientific system, with 20% leaving the country and the rest being lost to science (Estado y Perspectivas de las Ciencias Exactas, Físicas y Naturales en la Argentina 2015). In recent years, 1269 researchers wanted to return to Argentina from overseas to continue their research careers but there were not enough research positions to absorb this outstanding group of investigators. Moreover, Latin American researchers in developed countries feel more appreciated than at home. Salary is not the only reason; researchers find more freedom, stability, resources, and grants to develop their scientific capacity to the fullest extent. Therefore, the temptation to continue a scientific career abroad is high. In Colombia, approximately 70–80% of the resources of COLCIENCIAS (Administrative Department of Science, Technology and Innovation) are directed to support post-doctoral fellows, but there are no funds to support the scientific project locally. Therefore, if institutions do not provide the resources for research, fellowship recipients leave to pursue investigations abroad in well-equipped laboratories, which usually results in their not returning home. Indeed, many post-doctoral fellows prefer to pay back their credit-fellowship rather than return to Colombia. Brazil's brain drain issues continue to grow after the endemic problem of the Brazilian body politic (Murati 2016). In contrast, despite losing many highly qualified professionals, Mexico has attracted foreign scientists to their institutions thanks to programs for the consolidation of science and technology and to the success of international cooperation programs (Didou and Durand 2013).

Conclusions

Although the picture presented in this essay is discouraging, we want to finish on a positive note. Our region has many young graduates who enthusiastically wish to make a career in science. Senior scientists must guide and stimulate these younger scientists to increase the depth of their scientific inquiries (Thomaz and Mormul 2014) and encourage them to contribute to the improvement of science in their home countries. The Latin American society has got used to expecting new science and technological developments to come from developed countries rather than from their own scientists. We need to generate closeness between our citizens and scientists through science education and the active participation of researchers in activities within the community (Quiroz 2016). There is still hope that Latin America will again be the scientific powerhouse it was in the past. Latin American scientists are bright, innovative visionaries and hard workers, as shown by the great success of Latin American scientists when they are provided with stability, resources, and the freedom to investigate. Latin American governments must follow the example of developed countries and invest in long-term research goals that are not subject to change by the transition from one political party to another. The scientific/

technological base of a country is constructed in a cumulative, interdependent, and competitive way (Gonçalves da Silva 2016). A robust commitment to research has a great influence on education and social justice too. We must all work together to advance the future of science in Latin America to create a productive environment for future generations.

Acknowledgements The authors thank colleagues from Latin America who helped with their opinions, discussions, and data. The referee comments contributed to improve significantly the manuscript.

References

Albornoz M (2002) Situación de la ciencia y la tecnología en las Américas. Centro de Estudios sobre Ciencia, Desarrollo y Educación Superior. Buenos Aires, Octubre de 2002, pp. 1–52

Arenas N (2006) El proyecto chavista. Entre el viejo y el nuevo populismo. Desacatos núm. 22, septiembre-diciembre 2006, pp. 151–170

Astudillo P (2016) Manifiesto por la Ciencia. Editorial: CATALONIA - Fundación Ciencia & Vida Colección: Ciencia & Vida. ISBN: 9789563244670

Benet Rodríguez M, López Torres L, Leiva Rangel R, Hernández Pérez E, Miranda Pérez Y, García Alpizar B (2010) El financiamiento de la investigación científica en las Universidades de las Ciencias Médicas de Cuba. Realidades, retos y aspectos legales. Revista Electrónica de las Ciencias Médicas en Cienfuegos ISSN:1727-897X Medisur 8:31–33

Cottani J, Oliveros-Rosen E (2016) Economic recovery in Latin America is still fragile as Brazil slowly emerges out of its recession. WWW.STANDARDANDPOORS.COM/RATINGSDIRECT OCTOBER 7, 1

Dallanegra Pedraza L (2004) La Universidad y la investigación científica en América Latina. Instituto de Investigación en Ciencias Sociales, Facultad de Ciencias Sociales, Universidad del Salvador. Documento de Trabajo No. 23, pp. 1–32

Didou S, Durand JP (2013) Extranjeros en el campo científico mexicano: primera aproximaciones. Rev Electrón Investig Educ 15:68–84

Donghi TH (2013) Historia Contemporánea de América Latina. Editorial Alianza, ISBN: 9788420676135

Erben M (2016) A lab in Argentina. Interview. Nat Chem 8:523–524

Estado y Perspectivas de las Ciencias Exactas, Físicas y Naturales en la Argentina (2015) ISBN: 978–987–46127-0-0

Gonçalves da Silva C (2016) Brasil: Ciência, tecnología e outras coisas. super.abril.com.br/ciencia/brasil-ciencia-tecnologia-e-outras-coisas/

Kreimer P (2016) Sin tantos avances en ciencia. La Nacion, jueves 9 de junio

Kuramoto J (2013) El Perú recién le da importancia a la ciencia, tecnología e innovación. El Comercio. Jueves 29 de Agosto del 2013

LaRosa M, Mejia GR (2015) An atlas and survey of Latin American history. Routlege, NY **ISBN-10: 0765615983**

Lemarchand GA (2010) National Science, Technology and Innovation Systems in Latin America and the Caribbean. Regional Bureau for Science in Latin America and the Caribbean. UNESCO 2010

Murati K (2016) A after Rousseff impeachment vote, what's next for Brazil? Global Risk Insights, April 19

Omoleke SA, Mohammed I, Saidu Y (2016) Ebola viral disease in West Africa: a threat to global health, economy and political stability. J Public Health Afr 7:534

Piñón F (2003) Ciencia y tecnología en América Latina: una posibilidad para el desarrollo. In: Temas de Iberoamerica, "Globalización, ciencia y tecnología", volumen 2, OEI

Puhle AJ (1987) Populismo en América Latina. Revista de Ciencia Política Vol. IX, No.1

Quiroz S (2016) Ciencia: El Pilar Ignorado en el Desarrollo de Chile. Ed. Universidad Santo Tomás y RIL Editores

Ruiz JC (2000) La investigación científica en Ecuador. Rev Ecuat Med Crít 2:1

Sánchez V (2016) Hacia dónde Va la Ciencia en México? Agencia Informativa Conacyt http://conacytprensa.mx

Schneider A (2014) América Latina hoy. Integración, procesos políticos y conflictividad en su historia reciente, Imago Mundi, Buenos Aires, pp. 210. ISNB 9789507931734

Schuster A (2017) Es la tecnología, estúpido! Diario Los Andes. Mendoza. Domingo 17 de Marzo 2017, pp. 4E

Thomaz SM, Mormul RP (2014) Misinterpretation of 'slow science' and 'academic productivism' may obstruct science in developing countries. Braz J Biol vol. 74, no. 3 (suppl.), p. S1-S2

United Nations Commission on Science and Technology for Development (2013) Science, technology and innovation in Latin America and the Caribbean region. January 9, 2013. Lima, Peru

UNESCO Science Report (2015) Towards 2030. http://en.unesco.org/node/252168.

Van Noorden R (2014) South America by the numbers. Nature 510:202–203

Xue J, Murthy B, Tran NT, Ghaffar A (2014) Goal setting and knowledge generation through health policy and systems research in low- and middle-income countries. Health Res Pol Syst 12:39

Zanotto SR, Haeffner C, Guimarães JA (2016) A colaboração na produção científica no Brasil e no mundo: um recorte das áreas do Essential Science Indicators. In: 5 Encontro Brasileiro de Bibliometria e Cientometria, São Paulo:USP. p.A81