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Introduction

The face of Latin American comparative biochemistry and physiology

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Abstract

Latin America has experienced a vigorous growth in scientific production since the 1990s, rising from 1.7% of the world's share of science publications in 1990 to 3.2% in 2000. This appears to be a consequence of increasing investment in tertiary education, especially at the doctoral level. However, such growth is not homogeneous among the nations of Latin America, being affected by many issues, such as economical power and expenses in science and technology. Biology - including comparative biochemistry and physiology (CBP) - is one of the scientific areas of tremendous growth in the continent. Thus, in order to celebrate the increasing participation of Latin America in the field of CBP, the editorial board of Comp. Biochem. Physiol. decided to organize a special volume dedicated to Latin American authors (CBP-Latin America). From May to November 2005, 52 manuscripts were submitted to CBP-Latin America from Argentina, Brazil, Chile, Cuba, Mexico, Uruguay and Venezuela. This opening issue contains the first two dozen manuscripts, highlighting the diversity of experimental approaches and the breadth and uniqueness of the biological systems available to researchers in Latin America. We hope that the CBP-Latin America project becomes a significant editorial initiative, one that will meet the goals of highlighting, integrating, and mapping CBP research in Latin America.

1. The CBP–Latin America project

As this volume evidences, the field of comparative biochemistry and physiology (CBP) has grown quickly in Latin America, where a number of outstanding laboratories have flourished in recent years. The idea to put together a special volume of *Comp. Biochem. Physiol.* dedicated to 'the state of the art' of CBP in Latin America was hatched out of the perceived need to bring together the diverse regional fields, promote collaboration among scientists in Latin American nations, establish themes of common interest, and set the groundwork for new international collaborations. Additionally, Latin American biochemistry and physiology often focus on unusual and poorly studied species, and this project should serve to highlight the many unique experimental systems that have been used in that part of the world. As we all know, even if we don't all slavishly adhere to the August Krogh principle (for each physiological problem to be studied there is an ideal animal model for research (Burggren, 2000; Bennett, 2003; Mommsen, 2004)), comparative models often provide new and exciting windows on unsolved problems. On a broader scale, our thinking is that this significant exposure of Latin American biochemistry and physiology will not only strengthen and empower regional efforts, but will be a future asset for the entire field of CBP. Learning about the progress of CBP in the diverse regions of the world should help the global community of comparative biochemists and physiologists to speak with a unified voice, and to invigorate a field that for much too long has been the 'poor cousin' of biomedical research.

When we first put out the word about this idea and started to solicit proposals (in August, 2004), the response was overwhelming and positive. Within a few months our project had attracted more than hundred paper proposals by authors from many Latin American countries. This project, originally conceived to produce a single issue of *Comp. Biochem. Physiol.* keeps growing and hopefully most Latin American countries will eventually be represented (see Table 5). The 24 papers contained in this opening issue, provide a first glimpse of the variety in experimental systems and approaches and involved the active input of over 70 external reviewers. Less than 20% of

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reviewers came from Latin American countries to assess the level of the contributions on an international rather than regional playing field.

The received manuscripts cover several areas, from broad ecophysiological topics to mechanistic, subcellular and molecular questions, and include remarkable systematic diversity (see references below). The volume series will encompass research on animal and fungi CBP, and will address topics as diverse as metabolism and endocrinology, proteomics and genomics, enzymology, oxidative stress, neurobiology, toxicology, ion transport, origins of life, reproductive physiology, thermobiology and ecological physiology (see Table 5). This project also aims to map CBP research in Latin America, not only to promote and encourage the vigorous and diverse research groups that already exist but we also hope that it helps to identify areas, approaches and technologies that are not yet represented.

2. The recent growth of science in Latin America

One consequence of the political difficulties endured by several Latin America countries between the 1940's and 1970's has been the exodus of thousands of qualified researchers, as recognized by the Argentinian and 1984 Nobel Prize winner Cesar Milstein who claimed that "we seem to be the world champions in our efforts to get rid of intelligence" (Latorre, 2001). However, during the 1980's and 1990's, Latin America was characterized by increased political stability and greater investments in science, technology and education (see Section 3). This tendency has proven effective, as the number of Latin American publications in science and engineering (S and E) grew from 1.3% of the world's production in 1981 to 3.2% in 2000. These relative numbers translate into a 3.7-fold growth in total number of S and E publications (Table 1). These numbers may look small when compared, for example, to Canada (with 4.6% and 5.3% of the world's publications and citations in 1997–2001, respectively; King, 2004), but are outstanding from the perspective of absolute growth. Latin American S and E scientific production has been growing since the 1980's at a rhythm only smaller than that of newly industrialized countries in Asia (UIS Bulletin, 2005; see also Tables 1 and 2). An important contribution to this trend comes from Brazil, where S and E production increased from 0.84% (1993–1997) to 1.21% (1997–2001) of the worlds' share, with a parallel increase in number of citations (King, 2004). Mexico, Argentina and Chile have also exhibited substantial increases in their scientific production, and the four above mentioned countries account for 89% of the Latin American S and E papers of 2001 (Hill, 2004; Table 2). Moreover, the citations of S and E papers from Latin America rose from 14% to 20% of the share of all emerging and developing countries between 1988 to 2001 (Hill, 2004).

Among the diverse topics covered by Latin-American science and technology in recent years, health, physiological and biological sciences have received particular attention. Biology, biomedical research and clinical medicine were much better represented (12.5%, 13% and 21%, respectively, of all S and E papers) than engineering and technology (8%) in 2001 (Hill, 2004). As an example of growth in biology, the number of Brazilian publications in *Comp. Biochem. Physiol.* increased from 2.5% of the journal's output in the 1980s' to nearly 4% in 2001–2004.

Many S and E studies performed in developing nations involve collaborations with researchers in developed nations (28.9% in 2000; UIS Bulletin 2005); representing between 47% and 79% of the S and E publications of Chile, Mexico, Argentina and Brazil (Hill, 2004). In contrast, co-authorship within Latin American countries are only a fraction (5% to 20%) of the collaborative papers from Latin America (Hill, 2004). Based on our experience as Latin American authors, and the preliminary statistics of this volume (out of 8 submitted manuscripts (from a total of 52) with authors of more than one

Table 1
Publications in S and E in selected group of nations

	Latin America and the Caribbean	NIC in Asia[3]	Sub-Saharan Africa	Arab States (in Africa and Asia)	Oceania
1981	1.3% (4963)[1,2]	0.6%	1%	0.6%	2.8%
1990	1.7% (7945)[1]	1.7%	1%	0.8%	2.8%
1995	2.2% (11,707)[1]	2.4%	0.9%	0.8%	3.1%
1997	2.6% (14,380)[1]	3.0%	0.9%	0.8%	3.2%
2000	3.2% (18,606)[1]	4.2%	0.9%	0.9%	3.3%

Percentages represent the share of world's S and E publications. All values are from the UIS Bulletin (2005). The world's publications in 1981 and 2000 were 371,346 and 584,982, respectively. North America and the European Union produced 36.7% and 40.2% of the world's share of papers in 2000. 1: Numbers in parenthesis represent the actual number of S and E publications by Latin America and the Caribbean. 2: According to Prat (2003), the output of Latin America papers (in S and E and social sciences, including articles not listed in the *Science Citation Index* or *PASCAL*) has risen from 5695 in 1981 to 28,258 in 2003 (1.3% and 3.5% of the world's output, respectively). 3: NIC: Newly Industrialised Countries.

Table 2
Publications in S and E in selected Latin America countries

	Publications in 1988	Publications in 2001	Growth from 1988	Publications per million inhabitants (1999–2001)
Latin America	5609	16,329	2.9 fold	n.a.
Brazil	1766	7205	4.1 fold	38.8
Mexico	884	3209	3.6 fold	31.8
Argentina	1423	2930	2.1 fold	77.8
Chile	682	1203	1.8 fold	75.7
Venezuela	292	535	1.8 fold	22.5
Colombia	86	324	3.8 fold	7.3
Costa Rica	55	92	1.7 fold	22.8
Uruguay[1]	n.a.	n.a.	n.a.	47.9

Values are from Hill (2004). The evaluations done by Hill (2004) produced 10–20% lower figures than those from the UIS Bulletin (2005) (see Table 1) due to different bibliometric evaluations (country publication counts by Hill (2004) were based on fractional assignments, i.e., a paper with two institutional authors from different countries was counted as one half of an article). 1: Total publications from Uruguay (including social sciences) were 74 in 1988 and 362 in 1999 (source: http://www.ccpg.fq.edu.uy/sp/bibliometria.shtml). Publications listed in PubMed were 48 in 1990 and 118 in 2001 (RICYT, 2003). n.a.: Data not available from Hill (2004).

Table 3
Economic and educational figures in Latin America and Canada

Nations (and HDI values)[1]	GDP[2]	Pop.[3]	Poverty (%)[4]	Education (% GDP)[5]	Tert. educ. (% spent in educ.)[6]	Tert. educ. (% GER)[7]	Personnel in R&D[9]
Canada (0.949)	856.5	31.6	n.a.	5.2	36.2	59[8]	3487
Argentina (0.863)	129.6	38.0	14	4.0	17.5	56[8]	715
Chile (0.854)	72.4	16.0	10	4.2	14.0	42	419
Uruguay (0.840)	11.2	3.4	4	2.6	21.5	37	370
Costa Rica (0.838)	17.4	4.2	9	5.1	18.8	19	533
Cuba (0.817)	32.3	11.2	n.a.	9.0	17.5	34	538
Mexico (0.814)	626.1	104.3	26	5.3	19.6	22	274
Brazil (0.792)	492.3	181.4	22	4.2	21.6	21	352
Colombia (0.785)	78.7	44.2	23	5.2	13.3	24	81
Venezuela (0.772)	85.4	25.8	31	n.a.	n.a.	27[8]	222

Comparison between the Latin America nations involved in this editorial project and Canada. 1: Nations ranked by Human Development Index (HDI, in parenthesis) of 2003. Source: United Nations Human Development Report (HDR 2005)—http://hdr.undp.org/statistics/data/. The HDI is calculated as 1/3 on life expectancy at birth, 1/3 on GDP per capita (in parity purchasing power—PPP) and 1/3 on education (adult literacy index and gross enrolment index). HDI for Latin America and the Caribbean (LAC) and OECD (a group of 30 industrial nations) were 0.787 and 0.892, respectively, in 2003. 2: Gross Domestic Product (US$ billions, 2003). Sources: RICYT (2003) for Cuba, and HDR 2005 for other countries. 3: Population in million inhabitants, 2003. 4: Population (% of total) living below 2 US$ per day (1998–1999 for Colombia and Venezulea, 2000–2001 for other countries). Source: Unesco Institute for Statistics report (UIS report 2005)—http://www.uis.unesco.org/profiles/selectCountry_en.aspx. 5: Public expenditure on education (as % of GDP, 2000–2002). Includes capital expenditures, salaries, books, telecommunications, travel, etc. Source: UIS report (2005). 6: Public expenditure on tertiary education (% of all education levels, 2000–2002). Source: HDR (2005). 7: Gross enrolment ratios (GER) in tertiary educ. (% of the population of tertiary age in tertiary educ., 2002–2003). Source: UIS report (2005). 8: Source: EFA Global Monitoring report (2005), Unesco (data of 2001)—http://www.efareport.unesco.org/. 9: Researchers per million inhabitants (1996 for Costa Rica, 2000–2002 for other countries). Refers to people trained to work in any field of science who are engaged in professional R and D activity; most such jobs require tertiary education (UIS report, 2005). Values for LAC and OECD: 293 and 3046 per million, respectively (HDR, 2003). n.a.: Data not available.

country, only 1 study involved two Latin American nations), we suppose that a similar trend might apply to the field of CBP. Thus, although we perceive cooperation with developed countries as essential for the growth of Latin American CBP, this is not yet borne out in reality. We hope that this fairly comprehensive volume series will break the perceived regional isolation and catalyzes further cooperative efforts.

3. Investment in science and education in Latin America

Table 3 shows some demographic values for Latin America in comparison with Canada (which lags behind other major industrialized nations in contributions to research and development (R&D), but not in education spending per se). Investment in education in 2000–2002 was fairly similar in the Latin America nations and Canada (4.0–5.2% of GDP), except for Uruguay (2.6%) and Cuba (9%). The percent of educational expenditure employed in tertiary education was also similar among several Latin American countries (17% to 22%), although Colombia and Chile showed lower figures. Enrolment in tertiary education ranged 19% to 37% in various Latin American countries; substantial higher figures are observed in Chile, Argentina and Canada (42–59%). Whereas Canada invested 1.9% of its gross domestic product (GDP) on R&D in 2003, and most developed nations spend about 2–3% of their GDP for R&D, this index typically ranges between 0.3% and 0.6% for Latin America nations in recent years (Table 4). Brazil exhibits a greater investment (about 1% of GDP), while Colombia and Uruguay show lower figures (about 0.2%).

Under the above scenario, we need to ask what social and economic indicatives relate to the global rise in the numbers of Latin American S and E publications. Money allocation to S and E apparently has not been the chief factor (Holmgren and

Table 4
Doctorates (PhDs) graduated in selected Latin America countries and Canada and their investments in research and development (R&D)

	PhDs (1990)[1]	PhDs (later year)[1]	Growth from 1990	R&D (1990–1996)[3]	R&D (2003 or as marked)[3]
Brazil	1410	8094 (2003)	5.7 fold	0.76% (1990)[4]	4.8 US$ — 0.95%[5]
Mexico	201	1683 (2003)	8.4 fold	0.22% (1993)[4]	2.6 US$ — 0.40% (2002)
Argentina	n.a.	408 (1996)	–	0.42% (1996)[4]	0.52 US$[6] — 0.41%
Cuba	233	407 (2002)	1.7 fold	0.70% (1990)	0.21 US$ — 0.65%
Chile	29	114 (2003)	3.9 fold	0.51% (1990)[4]	0.44 US$ — 0.60%
Colombia	n.a.	38 (2002)	–	0.29% (1995)	0.14 US$ — 0.17% (2001)
Uruguay	n.a	76 (1998)[2]	–	0.25% (1990)	0.03 US$ — 0.22% (2002)
Canada	2673	3773 (2000)	1.4 fold	1.5% (1990)	16.6 US$ — 1.9%

1: Doctorates graduated in all areas (n.a.: data not available). Source: RICYT (2003). 2: For more information on PhD graduates in Uruguay, see: http://www.rau.edu.uy/pedeciba/. 3: R&D expenditures shown as values in US$ billion and/or percent of GDP. Source: RICYT (2003). Data on R&D from 2001 to 2003 have been cross-checked by the values from United Nations Human Development Report 2005. 4: R&D values for Brazil, Mexico, Argentina, and Chile are 3.5, 0.9, 1.1 and 0.15 billion US$, respectively. 5: Investment ranged 0.98% to 1.02% between 2000 and 2002. 6: Similar value in parity purchasing power (PPP) when compared to 1996.

Table 5
Countries and research fields involved in the CBP–Latin America project

	Proposals (up to April, 2005)	Submitted manuscripts (Nov., 2005)[1]	PHY[2]	OXI	PTN	MET	Accepted (Nov., 2005)
Argentina	14	5	1	1	1	1	2
Brazil (São Paulo)[3]	31	13	4	1	5	0	4
Brazil (other states)	36	11	0	3	2	3	6
Chile	7	8	2	4	1	0	5
Colombia	2	0	0	0	0	0	0
Costa Rica	1	0	0	0	0	0	0
Cuba	1	1	0	0	0	1	0
Mexico	19	12	3	4	0	1	6
Uruguay	3	1	0	0	1	0	1
Venezuela	0	1	0	0	1	0	1
Total	113	52[4]	10	13	11	6	24[4]

Table showing the numbers of manuscripts handled for the CBP–Latin America project. 1: Several submitted manuscripts did not have a preliminary paper proposal. 2: The most represented fields were classic physiology (PHY), oxidative stress (OXI), protein science and enzymology (PTN) and metabolism (MET). Other fields with more than 1 submitted study were neurobiology (3 manuscripts), ion transport (3 manuscripts) and toxicology (2 manuscripts). 3: The state of São Paulo was considered separately because it represents about 1/3 of Brazil's GDP, making it the powerhouse of Brazilian science production. 4: Submitted studies and accepted manuscripts rose to 80 and 37, respectively, in mid February, 2006.

Schnitzer, 2004), as most Latin American countries reveal a modest investment in R&D (in some cases, spending has decreased from 1990 to 2000; Table 4), and the world's share of Latin American resource allocation to R&D has grown meagerly (from 2.8% to 2.9%) from 1990 to 2000 (UIS Bulletin 2005). Mexico stands out as an exception with its doubling of R&D spending between 1990 and 2003. This tendency has been paralleled by an eight-fold rise in PhD graduates (Table 4; 49% of those in S and E in 2001–2003 (RICYT, 2003)) and a four-fold increase in the number of S and E publications (Table 2). Brazil exhibits a relatively high publication output within Latin America (44% of Latin American S and E publications in 2001), and has also increased both resource allocation to R&D and the turnout of highly qualified human resources. According to RICYT (2003), Brazil exhibited in 2000 about 60 thousand professionals qualified to act in all areas of R&D, high numbers in comparison with Mexico and Argentina (21–23 thousand researchers). In 1981 only 551 Brazilian students obtained their PhD degree, but this figure grew to 1410 in 1990 and to 8094 in 2003 (70–71% of those in S and E). In parallel, a significant rise of BSc graduates in Brazil was also evident between 1990 and 2002: from 70.5 to 142 thousand new professionals in S and E (RICYT, 2003).

4. Final remarks

Through this brief essay on the 'state of the art' we have tried to offer a profile of Latin American sciences with emphasis on CBP research. We hope that the CBP–Latin America project becomes a significant editorial initiative, one that will meet the goals of highlighting, integrating, and mapping CBP research in Latin America (Table 5 shows the list of countries and research fields involved in this project). Below, we are listing the contact addresses of senior authors for the papers included in this issue (see twenty-four references with e-mails; Borges et al., 2006; Bozinovic and Gallardo, 2006; Dafre and Reischl, 2006; Dorea et al., 2006; Esteves and Ehrlich, 2006; Fanjul-Moles, 2006; Fernández et al., 2006; Moraes et al., 2006; Murad et al., 2006; Mut et al., 2006; Prodocimo and Freire, 2006; Ramos and Selistre-de-Araujo, 2006; Richardson et al., 2006; Rodrigo and Bosco, 2006; Rodríguez-Sosa et al., 2006; Santos et al., 2006; Sciara et al., 2006; Simpfendörfer et al., 2006; Soria et al., 2006; Stábeli et al., 2006; Suwalsky et al., 2006; Vázquez-Medina et al., 2006; Vega-López et al., 2006; Zenteno-Savín et al., 2006) and readers are encouraged to contact the contributors or guest-editors of this special issue for comments, additional information or procedures for new submissions. For additional information on researchers participating in this issue of CBP, see the websites of *Comp. Biochem. Physiol.* (http://www.CBPjournal.net) and of Dr. Hermes-Lima (http://www.antioxidante.net).

The recent formation of the *South American Society for Comparative Biochemistry and Physiology* provides further evidence that the field is strengthening and maturing in Latin America. The society is associated with *Comp. Biochem. Physiol.* and has been a voice for CBP within the continent since 1997. Dr. José Eduardo Bicudo from the University of São Paulo (jebicudo@usp.br) is the current president and contact person for the society.

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