Nanotechnology in Latin America at the Crossroads

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ABSTRACT

The development of nanotechnology in Latin America has accelerated in recent years. In this article, Guillermo Foladori summarizes and highlights many key social, technological, and regulatory changes in Latin America as nanotechnology emerges there. As many countries in Latin America begin to consider and implement national strategies with regard to nanotechnology, many of the risks associated with nanotechnology have been overlooked. As a result, people in some countries have reacted negatively to new developments and government programs in nanotechnology, despite the promises of many that nanotechnology may provide solutions to problems such as poverty and the environment. The best way to realize the gains of nanotechnology while minimizing its disruptive and harmful effects is for Latin American countries to pursue a steady, but sure course in which the potential risks of nanotechnology are given due consideration and evaluation.

I. INTRODUCTION

The year 2005 was an important year for nanoscience and nanotechnology in Latin America. Brazil increased federal funding for its nanotechnology program. In Mexico, the Senate Committee for Science and Technology declared itself in favor of the development of a National Emergency Program for investment in research and teaching of nanotechnology. In Colombia, the National Council of Nanoscience and Nanotechnology was created. But all this was not done without controversy; and it was in Argentina that conflicts in the scientific and political spheres were concentrated, with repercussions in the media. In Argentina, many of the things that took place in a short span of time might take longer than in many other Latin American countries.

II. LATIN AMERICA IN THE NANOTECHNOLOGY WAVE

The Ministry of Science & Technology ("MCT") in Brazil held a meeting in 2000 that brought together scientists to prepare an agenda for work on nanosciences and nanotechnology.[1] They prepared a list of the researchers who were involved in the field according to thematic and research centers and proposed a plan of action. In late 2000, it was estimated that there were around 200 researchers working

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1 Conselho Nacional de Desenvolvimento Científico e Tecnológico, *Reunião de Trabalho, Tendências em Nanociências e Nanotecnologias*, CNPQ.BR (Nov. 22, 2000), http://www.cnpq.br/noticias/noticia05_040401.htm (last visited Apr. 4, 2006).

in nanotechnology.[2] In 2001, the MCT, through the Brazilian National Research Funding Agency (the Conselho Nacional de Desenvolvimento Científico e Tecnológico or "CNPq") earmarked one million dollars to form cooperative research networks. Four networks were set up for nanostructured materials, nanobiotechnology, molecular nanotechnologies and interfaces, and nanodevices semiconductors and nanostructured materials.[3] In late 2004, a network on Nanotechnology, Society and Environment was created.[4] Additionally, there are funds from the MCT Millennium Research Programme, Financiadora de Estudos e Projetos ("FINEP"), from the Coordenação de Aperfeiçoamento de Pessoal de nível Superior ("CAPES"), and from the States of the Federation.[5] In the year 2004, the Brazilian federal government released its Pluri-Annual Plan (2004-2007), scheduling around $28 million for the Development of Nanoscience and Nanotechnology ("DNN") program.[6] The aim of the program is "to develop new products and processes in nanotechnology with a view to increasing the competitiveness of Brazilian industry."[7] The government reconsidered the original budget during 2005, increasing federal investment for 2005 and 2006 from the original $19 million to around $30 million.[8] In 2005, within the DNN, the BrasilNano Network was also set up. This network is one in which companies and research centers are involved in order to quicken the industrial and commercial development of nanotechnologies.[9]

México has concluded several agreements and collaborated extensively with national industries and transnational corporations (e.g., HP, Jabil Circuit, Motorota, Hitachi, Agilent Technologies, Calpine, InterGen, Mitsubishi, and Monsanto).[10] There are several universities and research centers working with nanosciences and nanotechnologies, and according to Mihail Roco, there are twenty research groups.[11] Up until late 2005, there was no federal program to finance, organize, or regulate nanotechnology, despite the efforts of some researchers from a variety of institutions to get it under way;[12] the Institution of

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[2] Conselho Nacional de Desenvolvimento Científico e Tecnológico, Comitê de Articulação, Programa Nacional de P&D em Nanociências e Nanotecnologias, Plano de Implementação: 2001-2005 (2001), www.cnpq.br/noticias/nano.doc (last visited Apr. 4, 2006).

[3] CNPq, Editais e Resultados, Resultados de Julgamento, Edital CNPq Nano Nº 01/2001, Propostas Nanociência/Nanotecnologia Resultado Final (2001), http://www.cnpq.br/resultadosjulgamento/resultado_chamada_01_2001_nanociencia.htm (last visited Apr. 4, 2006).

[4] Interview by Eduardo Geraque with Pablo Robert Martins, of the Institute of Technological Research of the State of Sao Paulo, in AGENCY FAPESP (Nov. 19, 2001), http://www.agencia.fapesp.br/boletim_dentro.php?data%5Bid_materia_boletim%5D=2875%20 (last visited Apr. 4, 2006).

[5] CAPES, *Programa Nacional de Nanotecnologia na Capes*, CAPES.GOV, http://www.capes.gov.br/capes/portal/conteudo/Historico_Nanotecnologia.pdf (last visited Apr. 4, 2006).

[6] By 2004, 78 million reales (Brazilian currency) was worth about 28 million dollars, but by the end of 2005 the rising exchange rate increased this amount in dollars to 34 million.

[7] Ministério de Ciência e Tecnologia, *Desenvolvimento da Nanociência e da Nanotecnologia*. *Proposta do Grupo de Trabalho criado pela Portaria MCT nº 252 como subsídio ao Programa de Desenvolvimento da Nanociência e da Nanotecnologia do PPA 2004-2007*, MCT.GOV.BR (2003), http://www.mct.gov.br/blob/2361.pdf (last visited Apr. 4, 2006); *see also* Ministério de Ciência e Tecnologia, *O Programa de Nanotecnologia*, MCT.GOV.BR (2004), http://www.mct.gov.br/Temas/Nano/programanano.htm (last visited Jan.5, 2006).

[8] Marina Lemle, *Brazil to Invest US$30 Million in Nanotech by 2006*, SCIDEV.NET (Aug. 30, 2005), http://www.scidev.net/News/index.cfm?fuseaction=readNews&itemid=2319&language=1 (last visited Apr. 4, 2006).

[9] Ministério da Ciência e Tecnologia, *Portaria MCT nº 614, de 1º.12.2004*, MCT.GOV.BR (2004), http://www.mct.gov.br/legis/portarias/614_2004.htm (last visited Oct. 10, 2005).

[10] VOLKER LIEFFERING, STUDY ON THE NANOTECHNOLOGY AND MICROSYSTEMS TECHNOLOGY SECTOR IN MEXICO (November 2004).

[11] *Id*. (citing Mihail Roco).

[12] Instituto Potosino de Investigación Científica y Tecnológica—San Luis Potosí, *IV Reunión de Nanociencias y Nanotecnologías, Hacia un Programa Nacional*, IPICYT.EDU (May 18-20, 2005), http://materials.ipicyt.edu.mx/nano2005/index.html (last visited April 12, 2006).

Scientific and Technological Research of San Luis Potosi played an especially important role in this regard.[13]

Most research groups have bilateral agreements with groups in the United States or Europe, and financing comes from various Mexican and overseas programs. The main agreement is probably the partnership established in 2004 between University of Texas-Austin, International Center for Nanotechnology and Advanced Materials and several centers from the National Council of Science and Technology ("CONACYT") and other universities.[14] According to a recent study,[15] the main fields of research in Mexico are the following: integrated circuits, microelectromechanical systems ("MEMS"), semiconductors, sensors, and development of new materials. It is possible that in 2006 the indifference of the federal government towards nanotechnology will change. In December 2005, the Committee for Science and Technology of the Senate of the Republic issued a report in favor of the preparation of a National Emergency Program for investment in research and teaching of nanotechnology.[16]

Colombia has a National System of Science and Technology that was set up in 1991. In 2004, the Technical Secretariat (Colciencias) selected eight strategic areas for the development of productivity and competitiveness of the Colombian economy. One of these areas was Advanced Materials and Nanotechnology.[17] In July, 2005, the National Council of Nanoscience and Nanotechnology ("CNNN") was established and assigned to the Colombian section of the Institute of Electrical and Electronics Engineers ("IEEE"). In the following August, the Research and Development Net in Nanotechnoscience was set up, addressing the following areas: auto-assembly, replication, and nanoscale control; cancer and nanotechnology; nanoelectronics and molecular electronics; nanophotonics, spintronics, and nanomaterials; computation nanotechnoscience; quantum and molecular computation; nanorobotics; bionanotechnology; and the ethical and social implications of nanotechnosciences.[18]

In August 2004, Costa Rica inaugurated the Laboratory for Nanotechnology, Microsensors and Advanced Materials ("LANOTEC"). It is the first of this type in Central America. It will work on research, design, and construction of microsensors and carbon nanotubes; its emphasis on this last topic is in agreement with the NASA Goddard Space Flight Center based in Maryland. The initial $50,000 U.S. funding package includes a "clean room."[19] "The construction of LANOTEC and the purchase of the

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[13] *Id*.

[14] *New UT Center to Promote Nanotech Research*, AUSTIN BUS. J. (Feb. 3, 2005), http://austin.bizjournals.com/austin/stories/2005/01/31/daily42.html (last visited Apr. 4, 2006).

[15] *See* LIEFFERING, *supra* note 13.

[16] Comisión de Ciencia y Tecnología, Senado de la República, *Dictamen de la Comisión de Ciencia y Tecnología a la propuesta con punto de acuerdo por el que el Senado de la Republica exhorta al CONACYT, a la UNAM y al Instituto Politécnico Nacional, y a todas las demás universidades y centros de investigación públicos y privados, así como al sector empresarial, para que instrumenten un programa nacional de emergencia*, GACETA PARLAMENTARIA, No. 145 (Dec. 15, 2005), http://www.senado.gob.mx/sgsp/gaceta/index.php?sesion=2005/12/15/1&documento=101 (last visited Apr. 4, 2006).

[17] JAVIER MEDINA VÁZQUEZ, INVESTIGACIÓN Y DESARROLLO TECNOLÓGICO EN COLOMBIA (2005), http://les.man.ac.uk/PREST/SCOPE/documents/National_Report_Colombia.pdf.

[18] CNNN, *Conferencia Internacional, Nanoforum Colombia 2005*, NANOCOLOMBIA.ORG (2005), http://www.nanocolombia.org/nanocolombia@ieee.org (last visited October 10, 2005).

[19] A "clean room" is a room where the materials, processes, and equipment must be protected from particulates, temperature, humidity, vibration, and any contamination. It also offers process utilities such as ultra high purity water, nitrogen, and compressed air. According to U.S. Federal Standard 209, clean rooms rate from class 10, where no more than 10,000 particles larger than 0.5 micron exist in a given cubic foot of air, to class 1 (the cleanest) where there exist no more than 100 particles. *Nano Meets Macro: Architecture, Engineering Combine to Create a Monumental Building for Tiny Technology*, ARCHI TECH (Sept./Oct. 2005), http://www.architechmag.com/Articles/detailArchitech.asp?ArticleID=2734 (last visited Apr. 4, 2006); *see also* Neil Springer, *"Clean" Rooms Are Eyed*, ALBANY NANOTECH (Dec. 28, 1998),

necessary equipment were funded by the Costa Rica-United States of America Foundation for Cooperation, the Costa Rican Ministry of Science and Technology's 'incentive fund,' and the Pro-Cenat Foundation."[20]

Chile has several research groups involved in nanosciences at a number of universities, including the following: the University of Chile's Institute of Research and Testing of Materials, the Department of Material Engineering and the Advanced Interdisciplinary Research Center for Material Science; Federico Santa Maria Technical University (which studies the physics of condensed matter or nanotechnology, and from whence the Millennium Scientific Nucleus project is run with the help of scientists from many universities in the country); the physics department of Catholic University, which receives financial aid from the Andes Foundation; the government-funded Fondo Nacional de Innovación y Desarrollo Científico y Tecnológico ("FONDOCYT"); and various international programs.[21]

With its experience in biotechnology, Cuba could become a big player in nanobiotechnology. In 2002, the Cuban Academy of Science and the Ministry of Science, Technology and the Environment voiced the need to incorporate nanotechnology into the offered study programs; this comes at a time when those study programs are under review. The main obstacle is the lack of modern equipment, which explains Cuba's great effort to obtain funding from overseas, participate in international research networks and establish agreements with laboratories in other countries. The strength of Cuba's technological infrastructure is the depth of training and qualifications of the Cuban scientists.[22]

Throughout the region, nanotechnology has been recognized as one of the four fields of strategic technological development. The Fourth Regular Meeting of the Inter-American Committee on Science and Technology ("COMCYT") of the Organization of American States ("OAS") was held in Washington, D.C. in April 2004. It took into account the subject matter covered in four workshops held in different countries over 2003-2004.[23]

A workshop held in Ecuador in December 2003 covered hemispheric policies for scientific and technological development in the Americas. It outlined four areas: biotechnology, clean technologies and renewable energy, information networks and technology, and materials and nanotechnology. In the case of materials and nanotechnology, the workshop identified several issues related to urgent needs, including the following: nanobiomaterials, nanotechnology based on optics, electronics, chemicals and environment, the implementation of mechanisms to promote collaborative research, the creation of networks for the development of human resources and training, activities to strengthen the scientific

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http://www.albanynanotech.org/News/index.cfm?step=show_detail&NewsID=30 (last visited Apr. 4, 2006). A rough estimation of a clean room rate level 1 is around 1.3 to 1.4 million dollars for each 1,000 square feet. Even for a clean room level 10, the amount given by LANOTEC is probably underestimated.

[20] Marco Vargas, *Costa Rica Opens Region's First Lab for Nanotechnology*, SCIDEV.NET (Sept.16, 2004), http://www.scidev.net/news/index.cfm?fuseaction=readnews&itemid=1602&language=1 (last visited Apr. 4, 2006).

[21] Catalina C. Correia, *Proyectos de las Universidades Chilenas: Chile a la Vanguardia de la Investigacion Tecnologica*, EDITION ESPECIALES EL MERCURIO (Mar. 30, 2005), http://www.edicionesespeciales.elmercurio.com/destacadas/detalle/index.asp?idnoticia=0131032005021X0040030&idcuerpo=370 (last visited Apr. 4, 2006); Universidad de Chile, *Desarrollan Materiales de una Millonésima de Milímetro*, SITIO WEB DE LA UNIVERSIDAD DE CHILE, http://www.pilleux.cl/cv/U-Noticias/U-noticias%20Pilleux.htm (last visited Apr. 4, 2006).

[22] Amaury del Valle, *El Increible Camino Hacia El Infinito*, SUPLEMENTO CIENTÍFICO TÉCNICO EN RED (2002), http://www.jrebelde.cubaweb.cu/secciones/en-red/2003/febrero_25_2003/infinito.htm (last visited Apr. 4, 2006); OBSERVATORIO CUBANO DE CIENCIA Y TECNOLOGÍA, ELEMENTOS INICIALES PARA EL ANÁLISIS SOBRE LA NANOTECNOLOGÍA EN CUBA (2002), http://www.occyt.cu/varios/informenano.pdf (last visited Apr. 4, 2006).

[23] OAS, *Final Report of the Fourth Regular Meeting of the Inter-American Committee on Science and Technology (COMCYT)*, OEA/Ser.W/XIII.3.4 (2004), http://www.science.oas.org/COMCYT/english/Resolution.htm (last visited Apr. 4, 2006).

community structurally in these areas; and advisory services for governments. The workshop addressed the need for education, technology transfer, and other issues. Surprisingly enough, the workshop produced not a word on nanotechnology regulations or risk assessment (e.g., in the areas of health, environment, and ethics) or socio-economic impacts.[24] This is even more surprising given that the workshops included participation from the U.S. and Canada, countries that address some of those issues in their own national nanotechnology initiatives.

The Network of Latin American and Caribbean MacroUniversities (Red de Macrouniversidades de América Latina y el Caribe) was created in 2002. The network is extensive and actually covers about thirty public universities from the region. In July 2005, the network created a Multilateral Research Program on Science and Technology in order to produce joint knowledge on various topics. The topics identified as of regional importance included the following: disaster prevention, nanotechnology, energies, biotechnology, environment, education, and society.[25] In February 2006, the first thematic meeting regarding nanotechnology was proposed to take place in La Habana with the aim of sponsoring regional integration on research and training of human resources; but the program was postponed with no certain data.[26]

III. ARGENTINA AT THE CROSSROADS

In October 2004, the Argentine Economics Minister announced publicly that the government was working on a plan for the development of nanotechnology and digital literacy. He said that he had requested the cooperation of the Lucent Bell Company for development of a support program. The deal would allow the use of the company's Bell Laboratories in New Jersey.[27] Through this agreement, Argentina would avoid having to build a "clean room" immediately, which would, according to the

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[24] OFC. OF SCI. & TECH., FUNDACIÓN PARA LA CIENCIA Y TECNOLOGÍA, OAS & GOV'T OF THE REPUBLIC OF ECUADOR, REPORT OF THE WORKSHOP: SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT IN THE AMERICAS (Draft, Apr. 1, 2004), http://www.science.oas.org/Components/quito/LastQuito_Workshop_report_English_041204.doc (last visited Apr. 4, 2006).

[25] Javier Cruz, *Universidades Latinoamericanas Se Unen para Investigar*, SCIDEV.NET (July 14, 2005), http://www.scidev.net/gateways/index.cfm?fuseaction=readitem&rgwid=1&item=News&itemid=2220&language=2 (last visited Apr. 4, 2006).

[26] Red de Macrouniversidades de América Latina y el Caribe, *Primera Reunión Temática de la Red de Macrouniversidades de América Latina y el Caribe, Nanotecnología y Nuevos Materiales* (2006), http://64.233.179.104/search?q=cache:V4c3OCeIAOYJ:www.imre.oc.uh.cu/macrouniversidades/plegable.pdf+Red+de+Macrouniversidades+P%C3%BAblicas+nanotecnolog%C3%ADa&hl=es (last visited Feb. 15, 2006). There are also some other research collaborations between Latin American Countries. An example is the Argentinean-Brazilian Nanotechnology Centre, created in November 01, 2005 with the purpose of integrating and coordinating efforts to enable resources and develop collaborative projects in nanoscience and nanotechnology. *See* Carla Almeida, *Brazil and Argentina Launch Joint Nanotech Center*, SCIDEV.NET (Dec. 12, 2005), http://www.scidev.net/news/index.cfm?fuseaction=readnews&itemid=2537&language=1 (last visited Apr. 4, 2006); *see also* Consejo de Investigaciones Científicas y Técnicas, *Nanotecnología en el Mercosur*, CONICET.GOV (Sept. 14, 2005), http://www.conicet.gov.ar/NOTICIAS/ACTUALIDAD/2005/September/035.php (last visited Oct. 16, 2005); *see also* Carla Almeida, *Brazil and Argentina Launch Joint Nanotech Center*, SCIDEV.NET (Dec. 12, 2005), http://www.scidev.net/news/index.cfm?fuseaction=readnews&itemid=2537&language=1 (last visited Apr. 4, 2006).

[27] Ricardo Sametband, *Argentina Invests US$ 10 Million in Nanotechnology*, SCIDEV.NET (May 12, 2005), http://www.scidev.net/News/index.cfm?fuseaction=printarticle&itemid=2089&language=1 (last visited Apr. 4, 2006).

minister, cost $400 million.[28] In addition to the nanotechnology project, they would also seek to increase the sale of computers from 800,000 to 2,000,000 per year.[29]

Five months later, April 2005 saw the formal launch of the Argentinean Nanotechnology Foundation ("ANF"),[30] complete with a federal budget of $10,000,000 over the next five years and a tight agreement with Lucent Technologies.[31]

This federal support for nanosciences and nanotechnology was to be expected. Argentina has centers of excellence in several sectors (physics, chemistry, and medicine) which were working on micro- and nanotechnologies. The National Commission on Atomic Energy ("NCAE") and especially their Balseiro and Jorge Sabato technology institutes were in collaboration with Lucent Technologies. Students from the Balseiro Institute paid visits to the Lucent laboratories, and both institutions collaborated on nanomanufacturing.[32]

Nevertheless, the Argentinean scientific community was surprised by the procedure and the focus of the presidential decree. As for the procedure, the ANF was created by presidential decree and thus did not need the approval of congress. But this procedure sidestepped Law 25.467, requiring all scientific activities to be coordinated by the National Agency for the Promotion of Scientific, Technological and Productive Innovation.[33] Furthermore, the creation of the ANF meant autonomy of decision making in terms of policymaking for science and technology, financing of execution and assessment of results, matters which, according to Law 25.467, should fall to the regulating powers of the Ministry of Education, Science and Technology and Productive Innovation.[34]

As for the focus, the decree to create the ANF benefited the NCAE and its research institutes, underscoring many research groups who had been involved in the field at other universities and research centers or with experience in research networks such as the members of the Argentinean-Brazilian Center for Biotechnology.[35] Furthermore, a seat on the board of directors was given to a representative from Lucent Technologies, which publicly placed in doubt the autonomy of the guidelines for nanotechnology in Argentina.[36] The top-down procedure generated an unnecessary bad feeling in the Argentinean scientific community.

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[28] This amount is overestimated, since a clean room level 1 of 15,000 square feet could cost $20 million, see note 3, *supra* and accompanying text, but it served to justify setting up the Argentinean Nanotechnology Foundation in agreement with Lucent Technologies.

[29] *Lucent Technologies Apoyará el Plan de Nanotecnología en Argentina*, GOBIERNO DIGITAL.COM (Nov. 8, 2004), http://weblogs.cfired.org.ar/blog/archives/001088.php (last visited Apr. 4, 2006).

[30] Argentina, National Executive Power Decree No. 380/2005 (2005).

[31] *See* Sametband, *supra* note 30.

[32] INSTITUTO BALSEIRO, CENTRO DE NANOCIENCIA Y NANOTECNOLOGÍA (2004), *available at* http://www.tandar.cnea.gov.ar/P5/nano/CNN.doc (last visited Apr. 4, 2006).

[33] LILIA PUIG DE STUBRIN ET AL., CÁMARA DE DIPUTADOS DE LA NACIÓN, PROYECTO DE RESOLUCIÓN, Resolución del M.E. NS 380/05 (2005), http://www1.hcdn.gov.ar/dependencias/ccytecnologia/proy/2.844-D.-05.htm (last visited Apr. 4, 2006); *see also* Ricardo Sametband, *Ten-Year Nanotechnology Plan Proposed in Argentina*, SCIDEV.NET (June 27, 2005), http://www.scidev.net/content/news/eng/ten-year-nanotechnology-plan-proposed-in-argentina.cfm.

[34] DE STUBRIN ET AL., *supra* note 33.

[35] In 2004, Brazil went through a similar conflict. The Ministry for Science and Technology announced its intention to create a national Micro and Nanotechnology Laboratory in São Paulo. The announcement raised tension in nanotechnology networks because it would mean special privileges for the center that would begin it all (the Luz Sincrotón National Laboratory) and because it would centralize research in São Paulo, when the intention of the DNN project was exactly the opposite: avoiding centralization. *Cientistas Questionam Criação de Instituto de Nanotecnologia*, JORNAL DE CIÊNCIA (July 29, 2004), http://www.jornaldaciencia.org.br/Detalhe.jsp?id=20386 (last visited Apr. 4, 2006).

[36] Sametband, *supra* note 33.

The reaction was immediate. A month later, the Argentine Physics Association issued a statement condemning the procedure by which the ANF was created and suggested that it should be adjusted to within the parameters of Law 25.467 and that it should include all the research groups working in the field.[37] In parliament, the Committee on Science and Technology of the House of Representatives made a request for information pertaining to the ongoing scientific research with funds from the U.S. Department of Defense[38] and indicated that Argentinean scientists had taken part in seminars organized by the U.S. Office of Naval Research ("ONR") in agreement with the Air Force Office of Scientific Research ("AFOSR") to detect excellence research groups working on nanoscience. The Committee also presented a Bill of Law for the creation of a National Strategic Plan for the Development of Micro and Nanotechnologies, requesting at the same time the dissolution of the ANF.[39]

The confusion was not limited to the scientific and parliamentary media. The creation of the ANF in a narrow relationship with Lucent Technologies got to the press and generalized the debate on nanotechnology and civilian society. The newspaper *Página 12* published articles showing the connection between Argentinean scientific research programs founded by the U.S. Department of Defense, including one on nanotechnology by the NCAE.[40] The National Committee on Ethics in Science and Technology then issued a statement suggesting the regulation of nanotechnology research and eventually limiting those financed by overseas armed forces.[41]

IV. SOME LESSONS TO BE LEARNED FROM THE BRIEF LATIN AMERICAN EXPERIENCE

The essence of nanotechnology is that, on the nanoscale, materials have different physical properties from materials with a larger size. Nanoscale materials possess different electrical, optic, reactive, and resistance properties, among others. For this reason, some theorize that nanotechnology may constitute a disruptive technology in that it expands to all levels of the economy and possesses a competitive advantage vis-à-vis products made using older technologies. The world may be faced with a new and powerful industrial revolution. Could this be a chance for developing countries to catch up?

In recent years, governments, scientists, and international organizations have cast the capacity of nanotechnology for improving the living conditions of the poor in an optimistic light. An example of this is the view of the *Task Force on Science, Technology and Innovation* of the U.N. Millennium Development Project.[42] The Canadian Joint Center for Bioethics ("JCB") also holds the belief that

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[37] ASOCIACIÓN FÍSICA ARGENTINA, COMUNICADO DE LA COMISIÓN DIRECTIVA ASOCIACIÓN FÍSICA ARGENTINA CON REFERENCIA AL DECRETO 380/2005 (2005), http://www.afa.df.uba.ar/docs/La_CD-AFA-con_referencia_al_decreto_380-05.pdf (last visited Apr. 4, 2006).

[38] LILIA PUIG DE STUBRIN ET AL., EL SENADO Y LA CÁMARA DE DIPUTADOS DE LA NACIÓN ARGENTINA, REUNIDOS EN CONGRESO, ETC., PROYECTO DE LEY MARCO PARA EL PLAN NACIONAL ESTRATÉGICO DE DESARROLLO DE MICRO Y NANOTECNOLOGIAS (2005), http://www1.hcdn.gov.ar/dependencias/ccytecnologia/proy/3.279-D.-05.htm (last visited Apr. 4, 2006).

[39] *Id*. At the time of writing this article, the bill of law had not yet been discussed in Parliament.

[40] Andrea Ferrari, *La Batalla Naval de los Científicos Argentinos* (hereinafter Ferrari, *LaBatalla*), PÁGINA 12, Sept. 25, 2005, http://www.pagina12.com.ar/diario/elpais/1-56973-2005-09-25.html (last visited Apr. 4, 2006); *Id*., *Comité de Ética para la Ciencia Argentina Pagada por la US Navy*, PÁGINA 12, Nov. 12, 2005, http://www.pagina12.com.ar/diario/sociedad/3-57141-2005-09-29.html (last visited Apr. 4, 2006); *Id*., *Dime Quién te Financia* (hereinafter Ferrari, *Financia*), PÁGINA 12, Nov. 2, 2005, http://www.pagina12.com.ar/diario/sociedad/3-58709-2005-11-02.html (last visited Apr. 4, 2006).

[41] Ferrari, *Financia*, *supra* note 40.

[42] *See e.g*., CALESTOUS JUMA & LEE YEE-CHEONG, U.N. MILLENNIUM PROJECT, INNOVATION: APPLYING KNOWLEDGE IN DEVELOPMENT 70 (2005), http://www.unmillenniumproject.org/documents/Science-complete.pdf (last visited Apr. 4, 2006).

nanotechnology can be used to help achieve five of the eight Millennium Development Goals.[43] The organizers of the conference for the *North-South Dialogue on Nanotechnology: Challenges and Opportunities*, hosted by the United Nations Industrial Development Organization in Trieste, Italy, put forward similar ideas.[44] This optimistic viewpoint is based on the technical potential of nanotechnology for application to the urgent needs of underprivileged populations and presents a strong argument to harness nanotechnology in developing countries. Nevertheless, over the past thirty years, the world has seen the rapid development of technology in such fields as microelectronics, information technology, biotechnology, and telecommunications; but this technological advancement has not helped to bridge the poverty gap. The United Nations Development Program found that inequality on a worldwide basis increased over the 1990s:

> The era of globalization has been marked by dramatic advances in technology, trade and investment—and an impressive increase in prosperity. Gains in human development have been less impressive. Large parts of the developing world are being left behind. Human development gaps between rich and poor countries, already large, are widening.[45]

When dealing with technological revolutions, the socio-economic context could be more important for the societal outcomes than the technical potentialities embedded.[46]

Almost all of the Latin American documents consulted set forth the following macro objective: By quickening nanoscience and nanotechnology, there will be an improvement in a country's competitiveness. This is stated explicitly in the bulletin of the OAS and repeated in texts from Brazil, Argentina, Costa Rica, and Mexico. The argument is that nanotechnology can improve competitiveness and overcome the problems of a slower economy and the associated problems of poverty. This accounts for the efforts in all countries to integrate industry and commerce with nanotechnology research. However, improved competitiveness is not the same thing as improving the standard of living of people at large. The case of China comes to mind here. China increased its competitiveness over the last few decades and has now become the fourth largest economic power in the world; however, inequality has increased despite the higher competitiveness and larger economy.[47] Neither is improved competitiveness a guarantee of greater democracy, empowerment, and public participation.

In the current world arena of fierce competition, business dictates the rules of science and technological applications. This seems to be the case with nanotechnology. After the U.S. program, launched in 2000, many Latin American countries jumped on the bandwagon without first having created the subjective social conditions to prepare for a transition to nanotechnology.

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[43] Fabio Salamanca-Buentello et al., *Nanotechnology and the Developing World*, 2 PLOS MED. E97 (2005), http://medicine.plosjournals.org/perlserv/?request=get-document&doi=10.1371/journal.pmed.0020097 (last visited Apr. 4, 2006).

[44] INTERNATIONAL CENTRE FOR SCIENCE AND HIGH TECHNOLOGY—UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION, AIDE MÉMOIRE OF THE EXPERT GROUP MEETING ON "NORTH-SOUTH DIALOGUE ON NANOTECHNOLOGY: CHALLENGES AND OPPORTUNITIES" (2005), http://www.ics.trieste.it/Documents/Downloads/df2552.pdf (last visited Apr. 4, 2006).

[45] UNITED NATIONS DEVELOPMENT PROGRAM, HUMAN DEVELOPMENT REPORT 19 (2005), http://hdr.undp.org/reports/global/2005/pdf/HDR05_chapter_1.pdf (last visited Apr. 4, 2006).

[46] Noela Invernizzi & Guillermo Foladori, *Nanotechnology and the Developing World: Will Nanotechnology Overcome Poverty or Widen Disparities?*, 2 NANOTECH. L. & BUS. 295 (2005); Guillermo Foladori & Noela Invernizzi, *Nanotechnology in Its Socio-Economic Context*, 18 SCIENCE STUDIES 67 (2005).

[47] Alejandro Rebossio, *El Dragón Dormido Despierta*, LA NACIÓN, Dec. 31, 2005, Section 2, at 1-2 (quoting the Chinese National Statistics Office). It is even disputable whether poverty levels were lowered. *See* Robert H. Wade, *Is Globalization Reducing Poverty and Inequality?*, 34 INT'L J. OF HEALTH SERVICES 381 (2004).

Beyond the differences between countries, the Latin American proposals are characterized by the following common themes: (a) failure to consider the possible socio-economic impacts of the new technologies; (b) failure to conduct studies into the health and environmental risks or the ethical implications associated with nanotechnology; and (c) failure to generate a process for widespread participation in the elaboration of the proposals, thereby reducing discussion to a select group of scientists.

Limited experience with nanotechnology provides no excuse. The concerns outlined above are common to the introduction of any new technology. It is even more surprising that all of the Latin American initiatives have had the support, direct presence or aid of international specialists—most from the U.S., but also from Europe and Canada—countries where these issues are on the discussion table.

V. POSSIBLE SOCIO-ECONOMIC IMPACTS OF THE NEW TECHNOLOGIES

We live in a world where patents dictate the possibilities of use and enrichment. Nanotechnology patents are concentrated in the hands of wealthy countries and multinational corporations.

In 2003, the five countries with the largest number of nanotechnology patents are as follows: the U.S. (5,228), Japan (926), Germany (684), Canada (244) and France (183). In addition, the five entities that obtained more patents related to nanotechnology included four multinational electronics companies and one university: IBM (198), Micron Technologies (129), Advanced Micro Devices (128), Intel (90) and the University of California (89).[48]

This means that the restructuring of industry on a worldwide scale will mean having to pay for new patents. In Argentina, as in Brazil and Mexico, the possibility that research into nanotechnology will lead to patents is one of the goals and economic arguments for investing in these new technologies. However, this is a two-edged sword. Even when new patents are registered, it is highly likely that the country as a whole will have to disburse much more for all the patents than it should pay for. This is a topic that has to be discussed in depth.

Another problem concerning the disruptive nature of nanotechnologies is their impact on commerce. It is likely that raw materials will become cheaper as a consequence of their being substituted by nanotechnologies and a fall in demand. The publication of the Action Group on Erosion, Technology and Concentration ("ETC Group"), *The Potential Impacts of Nano-Scale Technologies on Commodity Markets: The Implications for Commodity Dependent Developing Countries*, studies the cases of the markets for rubber, platinum and copper. There are nanotechnological procedures that will substantially improve the durability of automobile tires, the main market for rubber, and this could significantly reduce the worldwide demand for the product. Carbon nanotubes could become an effective competitor for copper cables, greatly affecting worldwide demand for this product. Platinum could be replaced by nanotechnology as a catalyst in converters, batteries, and other products. These are some examples of the pressure that countries which sell these raw materials will face when they begin to be substituted by nanotechnology products. The publication concludes as follows:

> Without critical planning and assessment, commodity dependent developing countries are more likely to be on the receiving end of nanotech's potentially adverse impacts—rather than active participants in shaping nanotech's role in society.[49]

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[48] ETC Group, The Potential Impacts of Nano-Scale Technologies on Commodity Markets: The Implications for Commodity Dependent Developing Countries (Nov. 2005), http://www.etcgroup.org/documents/SouthCentre.Commodities.pdf (last visited Apr. 4, 2006).

[49] *Id*. at 50.

There is also the matter of unemployment. The latest report of the work group on science and technology of the United Nations Millennium Program considers nanotechnology to be more important to the developing world because, among other things, it means reduced work, land, and maintenance.[50] However, the possibility of an increase in unemployment has not been considered by proponents of nanotechnology initiatives.

Last but not least is the labor education issue. The European Union is thinking of the need to redesign high school curricula in order to adapt it to the demands of nanotechnology. In the U.S., they speak of the need for change starting with elementary education.[51] So far, the nanotechnology programs in Argentina and Brazil and the discussions in Mexico only concern training elite scientists. Without a wide scientific basis, it is more likely that excellent researchers will end up going overseas to developed countries. Some important themes still are not being given due attention in Latin America.

VI. STUDIES INTO THE RISK ON HEALTH AND THE ENVIRONMENT AND ETHICAL IMPLICATIONS

Negative impacts on health and the environment have always been part and parcel of new technologies, as was the case with genetically modified organisms, or polychlorinated biphenyls ("PCBs"), which are persistent chemical composites that build up in living organisms including the human body and affect the hormonal system.[52] Harmful effects of certain nanoparticles are regularly being found in the health of living organisms and in the contamination of ecosystems. In early 2004, the ETC group published a list of the main scientific papers that demonstrated the adverse effects of nanoparticles, including the capacity to cross the blood barrier of the brain and contribute to cancer, among others.[53] There is some evidence that knowledge of these harmful effects has increased.

Neither the Argentine Nanotechnology Foundation nor the Bill of Law for the National Strategic Plan for the Development of Micro and Nanotechnologies consider these issues. The Mexican nanotechnology proposals, drafted by a group of specialists, also have failed to consider many risks associated with nanotechnology. Brazilian documents from the DNN project do not address these issues either.

Brazil, however, has a group known as "Nanotechnology, Society and the Environment" that insists on bringing these issues to the public dialogue. Without doubt, this omission will lead to further political conflict in the future. The deputy Duarte presented Bill of Law 5.076 in June 2005. If enacted, the law would govern the use and research of nanotechnology in Brazil.[54] The law received a negative reaction

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[50] Juma & Yee Cheong, *supra* note 42, at 70.

[51] C. L. Alpert, *Introducing Nanotechnology to Public and School Audiences*, *in* NAT'L SCI. & TECH. INST. CONFERENCE & TRADE SHOW ABSTRACTS (2004), http://www.nsti.org/Nanotech2004/showabstract.html?absno=581 (last visited Apr. 4, 2006).

[52] THEO COLBORN, JOHN PETERSON MYERS & DIANNE DUMANOSKI, OUR STOLEN FUTURE (1996).

[53] Organic Consumers Ass'n, *NanoParticles Shown to Cause Brain Damage* (2004), http://www.organicconsumers.org/foodsafety/nanobrain040504.cfm (citing publications by the ETC Group and others documenting the risks associated with use of consumer nanotechnology products).

[54] EDSON DUARTE, PROJETO DE LEI Nº 5.076 DE 2005, DISPÕE SOBRE A PESQUISA E O USO DA NANOTECNOLOGIA NO PAÍS, CRIA COMISSÃO TÉCNICA NACIONAL DE NANOSSEGURANÇA – CTNANO, INSTITUI FUNDO DE DESENVOLVIMENTO DE NANOTECNOLOGIA—FDNANO, E DÁ OUTRAS PROVIDÊNCIAS (2005), http://www.camara.gov.br/sileg/integras/297210.htm (last visited Apr. 4, 2006) *see also Projeto Regulamenta Uso e Pesquisa de Nanotecnologia*, JORNAL DACIÊNCIA (June 7, 2005), http://jornaldaciencia.org.br/Detalhe.jsp?id=28782 (last visited Apr. 4, 2006).

from the Commission on Economic, Industrial and Commercial Development.[55] People argued that the moment was not appropriate, that it would be an obstacle for development, and that it might restrict investments, among other things. Despite the negative reaction, however, the proposal may portend future regulation of nanotechnology.

Latin American countries will have to consider the various impacts of nanotechnology in order to effectively legislate with regard to nanotechnology. Effectively evaluating the impact of nanotechnology, however, is difficult in terms of lacking equipment and staff, and in terms of the additional costs that Latin American countries will hardly be able to cover. Without a clear policy based on precaution—another issue that is not being discussed—it is more likely that nanotechnology will expand without restriction.

VII. LIMITING THE DISCUSSION TO A SELECT GROUP OF SCIENTISTS WITHOUT PUBLIC DEBATE

In 2003, the Brazilian Ministry of Science and Technology held an online public consultation on the document prepared by the Working Group on Nanotechnology. Unfortunately, there were only sixty responses, most from universities (29) and institutes (17).[56] The results and commentaries can be consulted online.[57] In Argentina, there was consultation among some scientists, although less formalized than in the Brazilian case. In both cases, however, most of the civilian population remains ignorant of nanotechnology. The media scarcely mentions the topic, and at the academic level, the scientists that work with nanotechnology are seen as an elite privileged with extra public funding.

Given that nanotechnology can be used in different sectors of the economy and that, little by little, transnational companies and corporations are making agreements with public research centers, the question of who determines what topics to research and the priority of that research, within a national context of chronic shortages of resources for science and technology, is a relevant topic. Given the lack of public participation, any discussion that reaches the media could be a surprise and could worsen the contradictions. The Argentinean case can be considered a taste of what is to come in other countries. The possible guidance of Argentinean nanotechnology by a U.S. corporation was one of the arguments used to question the ANF in Argentina and to suggest its substitution for the National Strategic Plan for the Development of Micro and Nanotechnologies.[58] According to the critics, the ANF would work in association with Lucent Technologies, a corporation dedicated to communications and which, in 2004, won a contract approved by U.S. Defense Advanced Research Projects Agency ("DARPA") for $9,500,000 for four years involving the Space and Naval War Systems Center in San Diego. Under this contract, Lucent was to provide faster and safer microsystems for military applications.[59] The controversy surrounding the joint project of the United States Office of Naval Research and the Balseiro Institute of the Argentine National Atomic Energy Commission concerning nanomaterials for sensors reached congress not long afterwards.[60]

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[55] EDSON DUARTE & LÉO ALCÂNTARA, INDÚSTRIA E COMÉRCIO PROJETO DE LEI Nº 5.076, DE 2005 (2005) http://www.camara.gov.br/sileg/integras/315967.htm (last visited Apr. 12, 2006).

[56] Ministério da Ciência e Tecnologia, *Relatório Sobre a Consulta Pública ao Documento Elaborado pelo Gt de Nanotecnologia* (2004), http://72.14.203.104/search?q=cache:r-MuvaWqjz4J:www.mct.gov.br/temas/Nano/consultapublica_nano.pdf+Relat%C3%B3rio+sobre+a+Consulta+P%C3%BAblica+ao+documento+elaborado+pelo+Gt+de+Nanotecnologia&hl=es&gl=mx&ct=clnk&cd=1 (last visited Jan. 5, 2006).

[57] *Id*.

[58] *See* note 36, *supra*, and accompanying text.

[59] *DARPA Selects Lucent Technologies to Provide Nanotechnology for Advanced Military Systems*, PHYSORG.COM (Sept. 9, 2004), http://www.physorg.com/news1113.html (last visited Apr.4, 2006).

[60] *See* note 38, *supra* and accompanying text; *see also* Ferrari, *La Batalla*, *supra* note 40.

Argentina is at the crossroads because its ANF might be under discussion in parliament. However, the lack of impact studies regarding nanotechnology is also being questioned in Brazil, and some voices in Mexico have been raised in favor of treating nanotechnology with the same caution as genetically modified organisms. Latin America is at the crossroads between opting for the top-down pathway it has been treading, on the one hand, or reviewing nanotechnology public policy and generating wider public participation, on the other. Many scientists are betting on the former, suggesting that any delay means missing the wagon on nanotechnology. However, the fastest way is not always the safest. Latin American society is highly politicized and can lose in a short time what it took so long to build with so much effort. Perhaps the best route is one that is slow but sure, in a carefully thought out process of technological exchange that includes precaution, risk management, socio-economic impacts, and public participation.