

## Chapter 7

# Comparative Considerations and Conclusions

*Compared with most other countries, the business of Cuban biotech is exceptional for one simple reason: it has been an exclusively state-sponsored enterprise. Indeed, Cuba has a long and distinguished history in biotech due to Fidel Castro's commitment to developing science in the country. [Buckley et al. 2006]*

**Abstract** The noteworthy success of a small embargoed island in scientific development, and in particular in a typically US-dominated and capital-intensive sector like biotechnology, has attracted considerable interest and discussion among the analysts and specialists, since it shows features that are unique in the panorama of developing countries. Cuba's achievements in science and technology seem an exception with respect to what usually happens in other underdeveloped countries, excluded probably the biggest and richest ones. Even more exceptional is the development of biotechnology in Cuba. Some concepts are summarized, inspired from the most competent specialists in the field.

**Keywords** Biotechnology industry • Integration *versus* competition • Public research institutions • Full-cycle research-production • *Empresa Estatal Socialista de Alta Tecnologia* • Biotechnology in third worlds countries • Brasil • South Korea

### 7.1 The Intriguing Issue of Cuba's Scientific Achievement: Knowledge-Based Economy and State High Technology Company

Generally speaking, biotechnology is the quintessential capital-intensive product of advanced financial capitalism, it introduced an imperial relationship with nature which has opened the door to the proprietary ownership of living matter. The material interests that underlie it, shape the very approach of biotechnology. Yet a small country like Cuba, with limited resources, has developed a successful, cost-effective

and efficient alternative to this world dominant approach. Almost two decades ago, in the most dramatic economic situation imaginable in Cuba, a specialist remarked:

one must ask why and how a small developing nation like Cuba could even contemplate the use of biotechnology as part of a national economic survival strategy. Even among Western industrialized countries, only Japan made biotechnology part of its national development strategy. Moreover, few biotechnology companies in the United States are successful, and all are seeking alliances with transnational pharmaceutical companies in order to gain access to capital and marketing networks (Feinsilver 1993b).

The reasons of the Cuban success in this field have attracted considerable interest and discussions among the specialists in the field (Feinsilver 1993a, 1995; Elderhost 1994; Kaiser 1998; Thorsteinsdóttir et al. 2004b, c; Giles 2005; Buckley et al. 2006; López Mola et al. 2006, 2007; Evenson 2007; Editorial 2009; Lantigua Cruz and González Lucas 2009; Cárdenas 2009; Reid-Henry 2010; Scheye 2010; Starr 2012). But before trying to summarize the arguments brought in these studies, we would like to start with an absolutely general consideration.

Must we really wonder of the swift progress of science in Cuba since the 1960s, and in particular of the almost sudden development of biotechnology at an international standard? How was it possible? Was it a unique case? Cubans are not extra-terrestrial creatures, gifted with superior intelligence or skills. They are on the average absolutely normal persons. In our opinion and experience, some degree of inventiveness, or resourcefulness, the art of scrapping, must be acknowledged to the Cubans (essentially the same that allows to the ancient American cars to continue to circulate in Cuba, despite the lack of spare parts since almost 60 years). But this cannot be a credible explanation.

Therefore, we must change the question. Did in the situation of revolutionary Cuba exist some peculiar condition, or a mixture of conditions, which provided to the Cubans particular motivations or stimuli that stirred their creativity? From that standpoint, various arguments can be proposed.

In the first place, the success of the Cuban revolution put the country in complete contrast with the most powerful imperial power. The Cubans have a dose of pride. Not only the survival, but even the success of the revolution became in some way a goal that, galvanized by Fidel Castro and the revolutionary leadership, was picked out by all the Cubans (obviously, those who did not leave the country) like a challenge, or a bet, in which the whole population put all its willingness, talent and fantasy. It seems at least plausible that a sort of collective will arose, which multiplied forces and opportunities. In particular, the speeches of Fidel strongly pushed in this direction, as well as the (however, or precisely because, strongly idealistic) “Che” Guevara’s voluntary work and moral stimuli, establishing an effective *hegemony* (in Gramsci’s words, Sect. 1.5, “conquering ‘ideologically’ the traditional intellectuals”).

In this context, in particular the Cuban scientific community was loaded with social responsibilities and goals that presumably strongly stimulated their will. In a sense, the usual ideology of the progressive role of science, which is generally assumed in an abstract sense by the scientific community, developed concrete tasks and commitments.

In general terms, Cuban science developed a peculiar model of scientific organization and structure. It deeply differed, in our opinion, not only from the privatistic organization of capitalistic countries, but in several aspects also from the centralized direction of the Soviet organization. With respect to the first one, the social tasks and the public needs were prioritized with respect to the individual careers and interests, and the hierarchies of power. With respect to the second one, there was in Cuba at the same time a collective and effective participation of the whole scientific community (even, in the initial times, of the student component, which was training to the scientific profession) to the basic decisions, and an enlightened and constructive planning from the political establishment, with the result that the social tasks prevailed. In particular, the career logic of scientific promotion and the privileges of the scientific elite were practically absent in Cuba (even though they acted as a mermaid for several scientists who left the country). Who has collaborated with Cuban scientists and scientific organizations should have been struck by the absence of competitiveness and rivalries, and from the highly collaborative spirit.

We shall try to summarize the main arguments discussed in the specialistic analyses we have cited.

Some of the factors that have made possible these accomplishments are: the availability of qualified human resources

a country of men and women of science,

a product pipeline already supplying the domestic health system and a growing export capacity, the design of facilities as integrated research-production organizations able to close the loop from research to the economic return, state guidance, social ownership, export orientation, and the comprehensive integration of the Cuban biotechnology multi-institutional system (Lage 2000). In a recent analysis (Lage 2013) the results of the Cuban biotechnology, in relation to their medical and scientific benefits as well as the features of the high-level state scientific organization (*Empresa Estatal Socialista de Alta Tecnología*, Socialist State High Technology Company), are discussed. Indeed, it cannot be denied that in Cuba biotechnology essentially represents a peculiar socio-economic experience of building connections between science and economy. The most influential among Cuban scientists, Augustín Lage, has elaborated in an original way the concept of “knowledge-based economy” (*economía del conocimiento*), meaning the direct transformation of knowledge into economic value, as a sort of substitute for economic capital (Lage 2006). As the concept is developed in a recent paper:

Valorization of knowledge generated by the fast advance of science and its marketing has led to the so-called ‘knowledge-based economy’ and as a consequence high-technology (HiTech) companies have emerged. Those based in Biotechnology have some specific features compared to other HiTech sectors. ... [Our] model is based on some concepts and proposals, and it addresses key elements, such as: insurance of adequate funding levels for R&D activities and technology replacement, flexible import and export management, the ability to get into very competitive markets and preservation of a highly qualified workforce. It also demonstrates the feasibility to establish this kind of enterprises in the context and regulations already existing in a non-capitalist environment, in the middle of the update of Cuban economy (Castillo et al. 2013).

## 7.2 Peculiar Features of Cuban Biotechnology Industry

Coming now to a systematic analysis of the peculiar features of Cuban Biotechnology industry, as they emerge from the specialistic literature, the following aspects seem relevant:

- The Cuban government had an unusual level of commitment to scientific and technological development, and a long-term vision to support health biotechnology, despite difficult economic conditions. Cuba took a first-world approach to the rapid generation and application of science and technology for economic development (Feinsilver 1995, 98).
- The Cuban government has placed social policy at the centre of its development policy. As a consequence, social needs have been guiding criteria for the choices and actions of the Cuban government.
- The Cuban government considered the development of universal education, free higher education, strong scientific training, and scientific research a pre-condition.
- Access to an educated workforce and a well-functioning public health system contributed to innovation:

The educational level of Cuba's labour force at the end of the 1990s was almost equal to that of the Organization for Economic Cooperation and Development (OECD) countries (Thorsteinsdóttir et al. 2004b, 21).

- Public research institutions form the backbone of health biotechnology:

some university institutions have made impressive contributions to health biotechnology. For example, researchers from the Faculty of Chemistry at the University of Havana made a leading contribution in the development of the synthetic *H. influenzae* type b vaccine<sup>1</sup> (Thorsteinsdóttir et al. 2004b, 21).

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<sup>1</sup>*Haemophilus influenzae* type B, or Hib, is a bacterium estimated to be responsible for some three million serious illnesses and over 350,000 deaths per year, chiefly through meningitis and pneumonia. Almost all victims are children under the age of five, with those between four and 18 months of age especially vulnerable. Hib meningitis is a more serious problem in developing countries, with mortality rates several times higher than seen in developed countries; it leaves 15 to 35 % of survivors with permanent disabilities such as mental retardation or deafness. However, Hib is preventable—highly effective vaccines have been available since the early 1990s. Yet hundreds of thousands of children die year after year from Hib disease. One major reason is that the Hib vaccine is significantly more expensive than other childhood vaccines; for a low and middle income country the Hib vaccine costs roughly seven times the cost of vaccines against measles, polio, tuberculosis, diphtheria, tetanus, and pertussis combined (about \$7 USD versus \$1 USD). In Cuba, national research and policy organizations have joined forces to implement an integrated strategy governing vaccines from the development stage to the distribution stage. This strategy brings together institutions involved in every life stage of a vaccine (including government ministries, clinical research organizations, support institutions and manufacturing facilities). [...] Thanks to the development of capacities and facilities to internalize the entire supply chain of vaccines, Cuba has been able to develop various vaccines and antibiotics at low cost while ensuring distribution of these life-saving advances throughout the country. In 1999, the first

- Many public research institutes house diverse health biotechnology activities, including research, development and production.
- Knowledge sharing and flow among and within research institutions have been an important stimulus for innovation (integration *vs* competition).
- Cuba's health biotechnology research system has strong links with the country's public health system, which is not only the recipient of innovation but also a contributor. This has encouraged collaboration between basic and clinical researchers, and has promoted the adoption of cost-effective treatment options.

Some features have been enhanced, or introduced in the past two decades, in response to the crisis caused by the downfall of the Soviet Union, as for instance:

- Integration and collaboration within the institutes of the Scientific Pole of Havana (or Western Havana Bio-Cluster) have been reinforced.
- Greater emphasis has been placed on innovation from within Cuba (Thorsteinsdóttir et al. 2004b, 19).

Many of the institutes have developed the whole cycle or the closed cycle, from research, through development, production, quality control and commercialization of the end products. Some institutions have even acquired a commercial arm, often in the form of an associated company (Thorsteinsdóttir et al. 2004b, 21).

- Cubans have been active in licensing and setting up strategic alliances and joint ventures based on Cuban biotechnology with companies around the world:

In addition to collaborative ventures with Canada and Great Britain, Cuba presently licenses its biotechnology and has joint projects in a growing number of developing countries around the world, including Algeria, Brazil, Canada, China, India, Malaysia, Mexico, South Africa, Tunisia, and Venezuela. In addition, China has become a major participant in Cuban biotech projects; three joint ventures have been formed in China using Cuban technology (Evenson 2007).

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(Footnote 1 continued)

commercial vaccine containing a synthetic carbohydrate antigen was developed in Cuba against Hib. This vaccine, Quimi-Hib (Heber Biotech), exhibits several advantages over naturally-derived vaccines, such as lower production costs compared with conventional vaccines, and higher quality control standards compared with naturally-derived agents. In clinical trials, also conducted in Cuba, researchers found that the HiB vaccine provides protection to nearly 100 % of immunized infants after primary vaccination and a second booster dose. Additionally, clinical trials showed the vaccine to be very safe. This lower-cost alternative provides access to the Hib vaccine for those who otherwise would not have been able to afford it.» (Pan American Health Organization, and World Health Organization, Vaccine Research and Development in Cuba, [http://www.paho.org/hq/index.php?option=com\\_content&view=article&id=3114%3A2010-vaccine-research-development-cuba&catid=6601%3Akbr-case-studies&Itemid=40275&lang=en](http://www.paho.org/hq/index.php?option=com_content&view=article&id=3114%3A2010-vaccine-research-development-cuba&catid=6601%3Akbr-case-studies&Itemid=40275&lang=en). Last access March 15, 2016.

As a result,

- Researchers in Cuba have filed about 500 patent applications in the health biotechnology sector based on more than 200 inventions (according to an analysis of the European Patent Office's (Munich, Germany) database: the European Network of Patent Databases, May 2003, <http://www.european-patent-office.org/>). These have been filed in several countries throughout the world, including the United States, Europe, Brazil, India, China and South Korea. Cuba exports biotechnology products to more than 50 countries, mainly in Latin America, Eastern Europe and Asia (Thorsteinsdóttir et al. 2004b, 19).

Cuba is now a location of choice, with major global pharmaceutical companies opening offices in Cuba (Scheye 2010).

### 7.3 Something Worth Thinking Seriously About: A Comparison with Other Experiences

By way of conclusion, it would be extremely interesting, and also valuable for the strategies of development and social progress of developing countries (but not only, if one takes into account the present conditions of subalternity of some nations into today's European Community) to draw some comparisons between Cuba and other Third World countries in scientific development and its achievements.

A general consideration drawn in a study of the late 1980s, when Cuban biotechnology was booming, still sounds relevant for the contrast with the strategic choices that Cuba had long since developed:

Third World countries are not pursuing scientific and technological policies leading to the development of strong biotechnological industries. Their leaders have been misled into believing that modern biotechnological industries can be built in the absence of strong, intellectually aggressive, and original scientific schools. Hence, they do not strive to reform their universities, which have weak commitments to research, and do not see the importance of having research hospitals able to generate excellent and relevant clinical investigation. These strategic gaps in scientific capability, the lack of governmental and corporate research funding, and the dependent nature of the chemical and pharmaceutical industries of the Third World make the development of competitive biotechnology a highly improbable event (Goldstein 1989).

According to Goldstein, at least at the date of his well-documented and argued study, contrary to the "biotech propaganda blitz", the tall tale of biotechnology and applied science as factors for meeting economic underdevelopment turns into its contrary, i.e. a factor of further exploitation of the economies of Third World countries, that is the defeat of the struggle to overcome subalternity. The Cuban exception could hardly be more evident.

Regarding Latin American countries, one should remark that at least some among them were not precisely "inexperienced" in the biomedical-biochemical field

(Goldstein 1989; Cueto 2006). In Argentina, Bernardo A. Houssay (1887–1971) was co-winner of the Nobel Prize for Physiology or Medicine in 1947. His school in Buenos Aires flourished with Braun-Menéndez (1903–1959), Luis Federico Leloir (1906–1987), 1970 Nobel Prize in Chemistry, and others. Another colleague of Houssay's, the Uruguayan Roberto Caldeyro-Barcia (1921–1996), pioneered the field of maternal-fetal medicine in Montevideo. Daniel Vergara Lope (1865–1938) in Mexico and Carlos Monge Medrano (1884–1970) in Peru made important contributions to high altitude physiology. In Brazil Maurício da Rocha e Silva (1910–1983) brought outstanding contributions to pharmacology, and was the chief architect of the development of this discipline. Guillermo Whittembury in Venezuela contributed to modern kidney physiology. However, in several Latin American countries the development of these disciplines, and of science in general, suffered deeply from the existence of military and repressive regimes. An exemplary case was the Argentinian pioneer in antibody research, and future 1984 Nobel Prize winner in Physiology and Medicine, César Milstein (1927–2002), who was exiled from the country in 1963 with his collaborators while he was trying to create the first group in molecular biology in the continent. He subsequently took British citizenship.

As a matter of fact, in the last few decades several developing countries have decidedly entered the business of biotechnology, among them the major Latin American ones, with different degrees of success.

Specific comparisons have been made between the development of biotechnology in Cuba and in some countries, other than the most industrialized ones, typically classified as

lower income countries or developing countries, each at a different stage of economic development when compared with industrially advanced nations» (Thorsteinsdóttir et al. 2004a, c; also Peritore and Galve-Peritore 1995).

However, we are aware that, in order that these comparisons make sense, they should consider, in the first place, the great difference between Cuba's "dimension"—economy, resources, population, and so on—and the majority of the other countries taken into account. Moreover, Cuba has a very peculiar geostrategical and political situation, not to mention the unique economic constraints due to the US embargo.

In this perspective, even more exceptional is the fact that, as we did already remark, Cuba kept increasing investments in health and medicine in the 1980s and the early 1990s, while the politics of economic austerity and financial constraints was predominant in the continent, and has confirmed this support as a strategic choice even in the extremely difficult conditions following the downfall of Soviet aid and trade.

Regarding specific features, in contrast with the level of integration of the Cuban biomedical system, in the other countries,

... lack of collaboration and linkages among health biotechnology institutions restrained innovation efforts. In China, lack of collaboration prevented its scientists from being the first in the world to sequence the severe acquired respiratory syndrome (SARS) virus. Lack of linkages, especially between universities and industry, has also slowed innovation efforts in Brazil and Egypt (Thorsteinsdóttir et al. 2004c, 50–51).

In Brazil, moreover, along with some public research institutions, universities are the main actors in health biotechnology.

Knowledge flow to and from Brazilian universities and public research institutes is however limited, as they are not well connected to enterprises (Ferrer et al. 2004).

Governmental policies are deficient.

Brazilians get lost between basic research and its transformation into technology, between academic life and the manufacturing system (Thorsteinsdóttir et al. 2005, 102).

University professors are often skeptical about close associations with companies. For their part, private sector firms lack linkages.

Particularly interesting seems a comparison between Cuba and South Korea, a country that was created after the Korea war (1950–1953), almost at the same time of the new revolutionary Cuba. Even South Korea has explicitly aimed to technological and scientific growth for its economic development, especially applied sciences, with a strong support from the United States, which conceived the country as a bastion against Communism (something symmetrical to the conception of the Soviet Union with respect to Cuba). South Korea has especially developed electronics and nuclear technology, reaching fore-runner levels, but also a strong healthcare biotechnology sector was promoted. Along with recent specific studies (Park and Leydesdorff 2010; Kwon et al. 2012), the connections between university, industry and the government in South Korea apparently reveal serious deficiencies. In fact, the inter-institutional

collaboration pattern, as measured by co-authorship relations in the *Science Citation Index*, noticeably increased, with some variation, from the mid-1970s to the mid-1990s. However, inter-institutional collaboration in the first decade of the 21<sup>st</sup> century was negatively influenced by the new national science and technology (S&T) research policies that evaluated domestic scientists and research groups based on their international publication numbers rather than on the level of cooperation among academic, private and public domains. The results reveal that Korea has failed to boost its national research capacity by neglecting the network effects of science, technology, and industry (Park and Leydesdorff 2010).

South Korea seems already a difference with respect to Cuba. A closer comparison of the fields of biotechnology (Wong et al. 2004) shows that in South Korea the healthcare biotechnology sector was promoted as a future source of economic wealth. This inflated political and investor expectations, with insufficient awareness of the high-risk nature of the field, and consequent danger that many enterprises fail in the process. Successful reverse engineering, combined with a comparatively inexpensive workforce, enabled South Korean companies to produce quality goods at a lower cost. In contrast, R&D in academia and industry did not place enough emphasis on innovation. Despite the positive indicators surrounding prospects of the sector, a single major technological and commercial breakthrough that will place South Korean biotechnology in the same league as that of the United States or the United Kingdom has not yet appeared. Despite government investments in the



sector, investors seem sceptical, especially after the venture mini-bubble of the late 1990s burst.

South Korea must evolve from the industrial learning paradigm to a new technology creation paradigm. For academics and policy makers, this sort of transition makes intuitive sense. For South Korean scientists, investors, entrepreneurs and the public, however, this paradigm shift is not simply an academic problem, nor easily manipulated through top-down policy instruments. Rather, at its most basic level, the move toward technological creativity requires an attitudinal shift. It cuts to the core of the post-war South Korean mind-set. Indeed, this may prove to be South Korea's biggest challenge in making it in biotechnology (Wong et al. 2004, 46).

A general remark about the Third World is that there,

biotechnology ... is a bibliocentric creed, in which the practitioners limit themselves exclusively to relearning technologies invented by others. Universities do not train people for invention and discovery but rather to follow and repeat what has been invented elsewhere. In fact, originality and inventiveness in the Third World, are, more often than not, persecuted and punished. The social blindness regarding innovation means that the scientific uses and social exploitation of the very few relevant discoveries made in the Third World mainly occur abroad (Goldstein 1995, 42).

The contrast to scientific development in Cuba could not be more complete!

## 7.4 Conclusions

In this book we have integrated our past and present experiences of active collaboration with Cuban scientists, and of research on Cuban science, with the most influential analyses of Cuban biotechnology accumulated in recent decades by the specialists in the field. We hope therefore to have reconstructed and analyzed in a convincing and complete way the uniqueness of Cuba's endeavour to face the high technology challenge, an endeavour based on an alternative concept and optimization of the human resources of Cuban society. Though at times our personal feelings may have shown through in the words we use, this does not invalidate the objectiveness of our main conclusions, which are not a matter of words but of facts, that we feel to have exhaustively quoted. Whatever may be one's personal opinion on Cuba, we strongly feel that the relevance of the country's achievements deserves acknowledgement, as well as the original features of its experience.

Cuba's endeavour to develop in a surprisingly short time an advanced, multi-disciplinary and polycentric scientific system has no equal in developing countries of comparable size. The achievement of an autonomous level, on equal footing in collaboration and interchange with scientists and institutions in the most advanced countries, was confirmed by the resilience of the Cuban system under the tremendous shock of the collapse of the Soviet Union and the Socialist block. This event repeated the challenge of overcoming the risk of falling back into a situation of subalternity. Once again, Cuba had to rely on its own resources, in the most difficult situation of isolation and an even more total embargo. Once more the

challenge was overcome by revamping the scientific system, obviously selecting the sectors and the aims to privilege. In particular, biotechnology was confirmed as one of the backbones of Cuba's economic system.

At present Cuba faces a completely new situation. The unexpected opening by President Obama at the turn of 2014 has started a new phase, full at the same time of potential opportunities and great chances. The world political and economic situation should undergo deep transformations, besides great instabilities in the next times. Nothing will ever be as before, and no one can tell what the future has in store. For that reason we have decided to stop our reconstruction to the end of 2014. Anyhow, it seemed to us that it was a story that was worth telling.

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