Twelve essential and urgent truths about science in Cuba

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Abstract: These days we are witnessing a national debate on science and its function in Cuba as we build a prosperous and sustainable socialist economic model. Given the small size of our country and its lack of natural resources, our development has no choice but to be based on the production of high-tech goods and services arising from science, technology and innovation. How do we do this? It's the central question in discussing Cuban science. To answer the question we have to start from essential ideas arising from our historical experience. This article identifies twelve of them.

Cuban science is at a turning point. It faces a complex situation posed by deferred effects of the Special Period, revision of the economic model, and non-stop globalization of the economy. What's happening occurs in the context of a society that is successful as regards social indicators (education, health, security, employment and others), but limited in its economic performance by both internal and external factors, mainly the latter.

The Special Period was a long and difficult battle for the Cuban people, but a victorious one. As defined by data, primarily the gross domestic product (GDP), this stage lasted from 1990 to approximately 2005, when we matched the GDP of 1989 and resumed growth from that point on. We emerged and were moving ahead. The main social conquests remained, long blackouts disappeared, the service components of the economy expanded, and internal finances and external trade were balanced. National sovereignty, social cohesion, and the socialist orientation of the development project had been preserved. No one was abandoned; the people won.

But battles, even victorious ones, cause wounds. Now is the time to identify and heal them. How to do so was the subject of extensive discussions on documents of the VI and VII Congresses of the Communist Party of Cuba (PCC, 2016; 2018), and more recently on the Draft Constitution (Cuban Parliament, 2018). At the very center of Cuba's new battle is the economy, and under that heading, scientific and technological development.

We coped with the Special Period and will construct a prosperous and sustainable socialism, but it won't be a return to the 1980s. It will be different because the world is different. The world economy has changed under the pressures of technology and globalization. Small countries cannot base their sovereignty on economic self-sufficiency, which is impossible. They will protect their sovereignty through intelligence and by participating in the flow of goods, services, and knowledge running throughout the world economy.

Cuba's population is small and so, like China, does not have an enormous internal demand for attracting industrialization. There are no mineral and energy resources serving as a base for exports, as is the case with Venezuela and Bolivia. Nor are there enormous tracts of land for agriculture, livestock and agro-exports as found in Argentina and Brazil. Our lever for economic growth must be exportable goods and services based on science and technology, ones that offer high added value.

Making sense of our realities and possibilities becomes very complicated due to a mixture of long-term trends and short-term problems to which is joined other equally complicated issues. These include impaired financial liquidity, the dual currency, potential for attracting investments, wage and educational policies, migration dynamics, space for and content of planning, role of the banking system, functioning of state-owned enterprises, international relations, and more.

The third decade of this century won't be characterized as "a period." National and global trends will play out and far-reaching strategies will be implemented. That will be the time when special characteristics and potentialities mark the formation of the just, solidarity-based, socialist, and prosperous society that most Cubans want to build.

But our economic model also faces urgent problems and complexities. Some have to do with processes that supposedly bring us closer to our socialist project and others keep us far away. It's essential that those in the first category operate more quickly and efficiently. Historical experience demonstrates that occasionally it's very clear where strategic paths are leading to. That's when decisions become irreversible.

We must discuss, boldly innovate, and decide on options. Time is short. And scientific and technological development becomes a matter of national sovereignty. At times like these and in order not to be confused, we must return to essential ideas and solidify our consensus on them. As José Martí wrote in 1884, "There is an accumulation of essential truths that fit into the wing of a hummingbird and yet are crucial to public peace, spiritual elevation and national greatness."

We will succeed in forming consensus on those essential, urgent, and relevant truths in the area of science. We will thus be better able to interpret details and particular situations and create structures and strategies. Here I propose twelve of those truths.

1. Science was one of the foundational roots of Cuban nationhood.

One aspect that identifies our history is the place occupied by science in the emergence of the Cuban nation. More than hundred years of battles of ideas preceded armed struggle for our independence in the 19th century. This rebellion of thought, with antecedents already identifiable in the 18th century had several principal leaders, among them the priest Félix Varela during the first half of the 19th century, and the intellectual and revolutionary José Martí later in that century. Science was a weapon in both of their struggles and a foundational aspiration for the Cuban nation.

In his role as academician and teacher of philosophy, Varela defended science as a discipline and broke with the scholastic thought central to the founding of the Royal and Pontifical University of Havana. He was the first to undertake studies of experimental physics using instruments. In his thinking he linked science to independence and patriotism.

José de la Luz y Caballero and Felipe Poey followed his ideas and continued the battle for scientific education in Cuba, assuring its place in a national consciousness where ethics, science and politics were intertwined. Founded in 1861, Havana's Royal Academy of Medical, Physical and Natural Sciences was the first of its kind outside Europe. It was scientific and for students was elective and based on merit,.

José Martí surprises us by his level of information and the exactitude of what he knew about scientific and technological developments of his time. In his fascinating and extensive body of work, he left us chronicles and reflections on physics, chemistry, anthropology, and on earth, medical and agricultural sciences: "Let the spirit of education be bartered from scholastic to scientific [...] Let scientific teaching be like sap in the trees, extending from the root to the top of public education" (Martí, 1883).

Cuba was a pioneer in the introduction of technological advances such as railroads, vaccinations, sugar refining, and more. We emerged in the world as an already rebellious nation, reacting not only to political and economic domination, but also to dogmas and intellectual vassalage. We imagined we could absorb the best of scientific thinking, wherever its origin; enrich it with contributions of our own; convert it into the basis for our education; and make it a part of our culture.

2. **Scientific rationality and the idea of socialism have been linked since the beginnings of both.**

Socialism and scientific rationality were two ideas that emerged together in the 19th century. Rebellions against exploiters and struggles for a more just society have, of course, existed for a long time. But the idea of socialism, in the form we know it today, matured as a concept in 1867, the year of publication of Karl Marx's monumental work *Capital*. From then on, the socialist ideal would represent more than human aspiration for justice on moral grounds. It would also represent an objective consequence of laws governing the evolution of economic systems.

Marx and Engels were profound scholars of what was happening with natural sciences in their time. Marxian theories integrated revolutionary thought with rationalism and science, and mobilized millions of people. They were fulfilled half a century after Marx's death.

The first country to embark on the construction of socialism, the Soviet Union, was the only industrial nation to escape the effects of the great economic depression in the 1930s. Between 1929 and 1940, the USSR's industrial production tripled and its share

of manufacturing in the world rose from 5% to 18%. Compared to the United States in the 20th century, it produced 80% more steel, twice as much iron, and five times as many tractors. The rate of growth of the Soviet economy in the 1950s was higher than that of any country in the western capitalist world. Socialism turned the USSR into an industrial power within a few years. This feat was essential to its victory in the Second World War. In the 1950s and 1960s, the USSR led in the space race.

Science, a fundamental element of socialist thought since the 19th century, remained an integral part of the consolidation of the world's first socialist state. Thousands of young Cuban scientists shared in this experience.

3. **The Cuban Revolution incorporated scientific development in its project early and successfully.**

If we want to dismantle the explicit or implicit argument that scientific development must wait for "the good times" – when we've solved other more urgent problems – we can rely upon intellectual weaponry from Fidel Castro.

There's an emblematic phrase that marks Science Day in Cuba: "The future of our Homeland must necessarily be a future of men of science and of ideas." Fidel Castro said this first in January 1960, one year before the Literacy Campaign. Then, when the crisis of the European socialist camp was at hand in 1990 and when we faced the enormous task of defending our sovereignty, Fidel said: "Independence is not a flag, or a hymn, or a shield. [It's] not a question of symbols. Independence depends on development, [...] technology, [...] science in today's world." And in 1993, when the economic crisis of the Special Period bottomed out, he returned to ideas of how science works in the economy, explaining that:

"Science and the production of science must one day occupy the first place in the national economy. But we start from scarce resources, especially limited energy resources in our country. We have to move ahead on producing things through our intelligence. That is our place in the world; there will be no other."

Fidel spoke of science, and acted accordingly. Economic problems were much more difficult then than ones we may be facing now.

The 1960s vision of the future of science coincided with a sequence of related events: the literacy campaign; the building of many schools; the scientific education of thousands of young people; the printing of scientific books; the spread of university teaching; and the founding of the Academy of Sciences, the National Center for Scientific Research, and scientific institutions within the ministries of Public Health, Agriculture, and so on. There were collaborative programs with the USSR and other socialist countries, as for example: the joint Cuban-Soviet trip to the cosmos; the national system of scientific degrees; the research- production centers of biotechnology; creation of the Ministry of Science, Technology and Environment (CITMA); the University of Informatics Sciences (UCI); and more.

To name them all is impossible. Never before in an underdeveloped country has science been called upon so early to play a leading role in a revolutionary program. This is our historical heritage. It shapes our perspectives on this issue.

4. **The development of biotechnology beginning in the 1980s shows that it's possible under conditions specific to Cuba to build an industrial and export sector based on science.**

Cuban efforts in the biotechnology sector began in 1981 with the creation of the Biological Front and the Center for Biological Research (CIB), the first center for biotechnological production. This was a precocious debut in a barely emerging area. For Cuba, entering this field was not just another stage, but with the development of organizations for both research and production there was now a direct connection between science and economics.

Institutions emerged, one after the other. In 1992 they were grouped together as the Scientific Pole of Havana. Later on, in 2012, they were integrated within the pharmaceutical industry as the umbrella business management organization BioCubaFarma. Azcuba [the Sugar Ministry] had been integrated similarly. The Science Pole produced innovative drugs and vaccines that are now exported to more than forty countries. Over all BioCubaFarma now provides more than 60% of our own medicines.

For our purposes here, the important thing to note is innovation in organization rather than in molecular biology or immunology. Cuban biotechnology did not emerge as a development within the institutional and economic frameworks of the previous era. Continuity was broken and bold decisions were required. Let's look at the main ones:

A. The new institutions emerged from the budgeted sector and became companies later. Contrary to what some report and what many believe, the great innovations in the world – genetic engineering, the Internet, microchips, renewable energies, etc. – almost always come from budgeted state enterprises, not from the business sector. Later on, companies take over innovations, perfect them, and make them salable and marketable. But they don't originate them.

B. In order to promote the transformation, the socialist state made investments and did so before being able to calculate the costs that would be involved and the time-frame for recovering the amount that was invested.

In science-based productive sectors, the value of "feasibility studies" is limited. This is because these calculations imply hypotheses about the impact of innovations, their value, and their market penetration. But what will happen along these lines is unknown at the time of making investment decisions. Only the state can offer a vision of the future and take responsibility for the necessary assimilation of risks. To invest when investment is "safe," the standard advice, is the same as investing late.

C. Investment went beyond the expansion of scientific capacity to include creation of production capacity. The new centers were born with factories. The essence of the development of Cuban biotechnology was not in "doing good science" (which had already been done), but in connecting science with production and the economy, and in institutionalizing that connection.

D. The new centers had direct export and import functions: they were born with their own commercial companies. In small countries, the domestic market is so small as to be unable to absorb the fixed costs of research and complicated quality-control systems that are part of the package. Enterprises based on science and innovative products can become profitable only with exports, and the channels for these are so complex and specific to each technology that "general" exporting firms can't establish them. The decision that the new centers would have direct import and export responsibilities exposed them to the demands of external markets. But that decision provided them with an opening to resources and to expertise also.

E. For more than a decade, the new centers were protected by a system of prioritized attention. In classical business management, companies feel pressures to achieve short-term profitability. As a result they may be distracted from developing new products, which in their early stages are more costly to produce than already "mature" products. Obviously we have to make the transition at some point and assume business-sector rules, but only when the company acquires a certain maturity. For Cuban biotechnology, that happened in 2012, with the emergence of BioCubaFarma.

F. Funding for scientific research shows up in balance sheets under the heading of costs, not potential earnings. In industry, research-development (R&D) is usually financed through some of the profits, but in high-tech sectors any large investments have to be guaranteed, especially in the early stages, when profits are scarce.

G. Liquidity made available through convertible currencies was helpful for financing. In the early years funding flowed directly from the state reserves. It wasn't much, as some suppose, but it was predictable and transparent, and grassroots organizations made the decisions as to its use. When biotechnological products began to be exported, revenues in foreign currency were recycled through the same channel as the state reserve funds without having to compete with what was needed by other sectors of the economy.

H. Direct attention by the country's top political leaders allowed for agile decision-making, especially in international negotiations and investing. Wages were not linked to immediate economic performance, at least for the first two decades. That approach today might be controversial, but we are describing what happened.

I. Human capital was protected through a policy of collective wage stimulation linked to the economic performance of the entire sector and not to that of each institution, and even less to the performance of each individual. Many will be amazed at this decision, especially in light of current modalities, but it worked, and it was also a way of building

cohesion and integration, and ensuring consideration of the medium- and long-term view of things.

J. The centers were managed at close range and were supervised directly by the Council of State. Fidel himself was personally involved. That direct attention and certainty as to how the leadership was oriented represented both stimulus and moral commitment. But there was an economic logic too. Economic regulation usually exerts automatic pressures in terms of short-term profits, productivity, and wages being subjected to considerations of added value, etc. In this instance, however, such pressures were eased in order to protect organizations, encourage the long term view of things, and absorb risks.

At this point, ongoing qualitative evaluation was implemented as to what's happening in the institutions. Clearly, newly created institutions have to be protected, and even later on, they can't be left to evolve on their own since that might entail risks of inefficiency being protected and of lack of perspective.

Far from implying an erosion of respect for institutions, this strategy, advanced at the top level of state leadership, led to the building of institutions more appropriate to the new level of technological development and to special characteristics of institutions as they were emerging.

Can this story be repeated? With adaptations to the current context, we think it can be. To explain why, we have to analyze the innovations – organizational more than scientific – that accompanied the development of Cuban biotechnology, To achieve novel and audacious results, one has to propel them with novel management methods.

5. **The Special Period eroded Cuba's scientific potential, and effects continue.**

The strengthening of the US blockade at the time of the USSR's disappearance was an act of genocide against Cuba. Many tend to link the Special Period strictly with the disappearance of the socialist camp, which certainly had its impact. But we must remember the Torricelli Law, signed in 1992; the Helms-Burton Law of 1996, and the so-called "Bush Plan" against Cuba in 2004.

Organized harassment of Cuba's financial transactions mounted. Foreign trade fell by more than 80%, GDP by 35%. We went from consuming thirteen million tons of oil a year to less than three. Investment capacity contracted: gross capital formation, which reached 26.3% in 1989, fell to 5.2% in 1994. Real worker income also declined. Access to food and medicine was problematic.

Indicators of the volume and productivity of scientific activity eroded during this stage. Science was short on human capital. Because of its long-term orientation, science tends to recover from difficult economic times more slowly than do other areas of human activity. Special decisions on biotechnology, already mentioned, provided partial protection for this sector and promoted growth. But in many other sectors this kind of

protection was impossible and scientific activity contracted, especially in universities, where most human capital is found.

At the time of this writing (2018), the main indicators of the volume and social impact of scientific activity haven't recovered, although the GDP of the Cuban economy has surpassed the 1989 level. Expenditure on science and technology grew in recent years, reaching 0.7% of GDP in 2015. But that growth has been slow and does not reach the level of the most innovative countries, slower even than that of several Latin American countries. Furthermore, continuation of the double currency and double exchange rate prevents us from evaluating how GDP translates into the availability of real resources for science. In figuring costs in science and technology, we attach great weight to current expenditures and not so much to capitalization of investments in the system. It's a situation which perpetuates technological backwardness.

The number of workers associated with the science and technology system, including researchers, shows a decreasing trend. We rank eighth place in Latin America in the production of scientific publications. The portion of our exports dedicated to products of high and medium-high technology does not exceed 15%. We maintain a dangerous disconnect between our high capacity to generate human capital and our ability to translate that potential into economic growth of our products and services, and to added value.

These deficiencies stem from the Special Period. We must face them with the same energy, realism, and coherence with which we successfully solved problems at that time. Damage to our system of science, technology, and innovation is real, painful, and even perilous. It entails the risk of negative phenomena that can't be reversed, something we must face head on.

6. **For Cuba there will be no possible economic development in the 21st century without the infusion of science throughout the economy and not exclusively in niches of excellence.**

In today's world any production requires a large and growing content of knowledge and technology. An essential component of development is the "added value" of production, i.e. the difference between the value of material inputs and the final value of what is produced. That difference is created by work, but its transformative function increasingly depends on knowledge and technology. No country develops with many people producing a lot and with great effort but with little added value.

Argentine scientist Bernardo Houssay, Nobel Prize in Medicine in 1947, coined this phrase: "Rich countries are rich because they dedicate money to scientific-technological development, and poor countries stay poor because they don't" (*El Intransigente*, 2013). It's a beautiful phrase, but it's wrong. The origin of the division between rich and poor countries lies not in science, but mainly in colonialism, plunder, and the capitalist international economic order, which continues and is unjust.

But once liberating political processes, like the Cuban Revolution, put levers of power and resources of the economy in the hands of the people, then investment in human capital and, through this, in science, technology and innovation becomes decisive for economic development. The same is true for continuity of social development. Resources for financing public programs must include added value created by economic activity. These include extensive and decidedly just programs in education, health care, culture, social security, and more.

7. **Without scientific capacity there would be no capacity to assimilate foreign technologies.**

The ability to use knowledge and assimilate technologies from external sources increasingly is linked to capabilities of developing one's own scientific capacities. In this twenty-first century, technologies change a lot and rapidly. Through its experience of producing new knowledge, a society gains capacity to interpret, adapt, improve and assimilate knowledge generated in other countries.

Global experience indicates that foreign direct investment rarely supplies capacities to develop science and technology. These remain with parent companies intent upon retaining their power to continuously adapt and improve their own technologies. The recipients are left with the end stages of the production process. All they do is apply what is already known, and often do so badly.

8. **As a small country, Cuba's development depends on its ability to insert itself into the world economy**.

The levers of science and technology make this possible. Success or failure in this regard has implications for defending national sovereignty.

For small countries, the external economy is essential, specifically the value they capture from transactions throughout the world. International demand is evolving increasingly toward sophisticated and technically complex goods and services. What we can supply has to evolve in parallel fashion with this tendency.

In Cuba domestic demand is too small to serve as the main lever of economic growth, which centers on our insertion in the world economy. And of course we cannot do this with natural resources the way oil-producing countries do. Besides, prices of primary products – that is to say, raw materials – are continually falling. Our involvement in transnational productive chains and in the worldwide flow of goods, services and capital will occur through the levers of science and technology.

To produce high technology goods with added value is not profitable, with few exceptions, under conditions of small internal demand. That’s because of their high fixed costs and costs of capitalization. So the choice is clear: we either create capacities to export or we produce low-value goods and services. Moreover, in higher-income countries, investment tends to shift from tangible goods to intangible goods that become

directly tradable (scientific projects, patents, trademarks, etc.). Many poor countries can't produce intangible goods like these in large volumes. But Cuba, with its high educational development, is well positioned in this regard. This may be Cuba's opportunity to connect with the world economy and to construct productive transnational chains, and do so before costly concrete investments are required.

The effort would require effective strategies for enabling human capital to create intangible goods produced by state-owned companies and have the process financed through international negotiations. If we are unsuccessful at this, our international connection will be made through human capital itself, in other words with emigration of the high quality work force, which generates very little added value for the country.

9. **Socialism is not possible unless a country's economy is technologically developed.**

We need science and technology not only for our own development, but also for that development to be socialist in nature. Socialism is an objective consequence of the development of productive forces. Socialism did not take root in the 19th century despite the moral superiority of socialist distribution. Productive forces that are technically advanced are essential for socialization of production. They gain comparative advantage from a milieu of education, culture and social equity, which can only come from the budgeted investment of the socialist state. Furthermore, they turn the market into being an impractical form of interpersonal relations.

An economy of tiny shops linked by market forces would be a poorer economy, but also a less sovereign one and less socialist.

10. **Cuba's system of science, technology, and innovation has to grow and not in proportion to economic possibilities, but before this becomes an issue.**

This may be a controversial statement, especially in light of the current financial difficulties, but it points to an objective that is inescapable. Science and technology are not only consequences of economic development; they are the main agents propelling it.

Today the average number of researchers per million inhabitants in the world is 1,083. But in high-income economies that figure is 3,814. If we decided to match that ratio, we would have 42,000 researchers in Cuba instead of the 7,000 researchers we have today. The average spending on research and development in the world is 1.7% of GDP, a percentage that grew after the financial crisis of 2008. The equivalent figure for high-income countries is 2.31%. Ours is 0.7% of GDP, in line with the Latin American average. It should be tripled.

Numbers are always debatable, and there are nuances in calculation methods. But even with an approximation, the qualitative conclusion about what we do is that our

system of science, technology and innovation measures is too small to be a catalyst for development in all sectors of the economy and society.

There is a "volume effect" in scientific activity that renders its growth in productivity as being greater than that of linear growth. If you double the number of scientists you have more people working, but also more interaction among them. That leads to empowerment or criticism. Either of these expands productivity.

It may come as a surprise, but it's possible to change this situation, and radically so. Long ago we set out to be the country in the world with the most doctors per inhabitant, and we succeeded. Why not do the same with other scientists, whose absolute number will always be less than that of physicians? This is another "Sí, se puede " ("Yes, you can") that we could be proclaiming.

11. **The main task is to connect science with the economy and with operations belonging to enterprises of the socialist state. But also we must expand the presence of science in the budgeted sector of the economy.**

The task before us is not limited to the growth of scientific activity. This can be measured in terms of the number of scientists, institutions, publications, patents, etc. These measure the volume of activity, but they don't measure the connections of science with economics. Building those connections is most important. If they don't become solid and durable, science, at best, could end up functioning as a far-removed consequence of economic growth (through making resources available), but not as something that promotes growth.

The experience of the Cuban revolutionary process has been very successful in utilizing scarce economic resources to nurture social development. That is why we have enviable indicators of health, education, peace, and citizen security, among others, even though the country's GDP is small. But we have not been so successful in closing the loop and turning social development into a lever for economic development.

Of course, having abundant and high quality human capital is a necessary condition for that task, but it is not enough. We need good institutions that serve as connectors between science and economics and that transform human potential into economic achievements.

Those institutions mainly have to be socialist state enterprises that manifest social ownership over the means of production and socialist distribution that relates to work being done. They must carry out and protect medium-term investments. They must be enabled to carry out their assigned function through installation of an "absorption capacity" for science and technology. Scientific development not only means being able to generate knowledge, but above all, the capacity to use it. We have to intentionally build that into all of our companies in these ways: personnel being prepared for management; the structuring of relations among companies, universities and scientific centers; regulations that provide companies with capacities and incentives to make

medium-term investments; and reinforcement of companies' direct connections with foreign buyers in search of innovative products.

The connection between science and economics also comes about through reinforcing scientific activity in the budgeted sector. The need to augment participation of the business sector in the financing and management of scientific activity in that sector should not lead us to the extreme of trying to arrange for all science to have a business function. That sector does utilize the results of science, enriches them, and does bring them closer to applications in production and in services. But such a "harvest" ends up depleted unless it's replenished continually from the budgeted sector.

Science in the business sector consumes intellectual capital; it does not generate it. The social capacity to use science as a lever for development is guaranteed in the scientific institutions of the budgeted sector: universities, academic institutes, scientific activities in the health sector, and social sciences. Thus we not only achieve a capacity to capture and transmit knowledge but we also develop the process by which knowledge is created. Specifically we develop a culture of scientific thought. This takes root through carrying out research in educational institutions. They are the principal multipliers of culture, values and capacities.

12. **We can achieve this, but we will need financial and institutional creativity and creativity too in fashioning the international linkages of scientific activity.**

Science in Cuba was born and was institutionalized, and then grew and became productive as a project of the Revolution. Science, with its protagonist's role during sixty years of revolutionary construction, captured the imagination of hundreds of thousands of young people over the course of several generations. Scientists' resistance to the difficulties of the Special Period was heroic. Now science and scientists must prove they can continue doing the same in the new context marked by continuation of the commercial, economic and financial blockade of the United States, by contraction of investment capacity due to diminished internal savings, by the absence of a socialist sector in Europe, by right-wing and neoliberal governments in Latin America, and by a globalized economy with growing technological requirements. The latter is basically capitalist and predatory. The good news is that we can do everything that needs to be done. National sovereignty, the socialist character of our economy, and our already constructed technical and political culture provide us with the tools for doing so.

We will require business enterprises active in science and technology and scientific and university institutions better connected with them. We will have to create and implement the legal framework for this. Science centers and companies will have to change. We have to design specific space for "high technology companies" as well the form that other emerging companies might assume, beginning with academic institutions and universities. Our insertion into the world economy will involve negotiations in regard to intangible products and knowledge itself. The negotiations must be simple and agile. We will have to learn how to organize foreign trade on these foundations. Our fall-back

resource will be the staying power and diversity of our network of international relationships.

We must work hard, but with great creativity. Simón Rodríguez (1830), Bolívar's teacher, once said, "We invent or we err". Guidelines do not exist anywhere as to how a small country without natural resources gains access to development with levers of science, technology and socialism.

When we speak of creativity, we are referring to innovations not only in specific fields of science and technology, but also to the socio-economic and organizational innovations that must be inserted into the business macro and micro economies and in the budgeted sector.

Science, like other sectors, is built on three interacting ingredients: the people, the resources, and forms of organization that connect them. We can't advance on the basis of only one point of that triangle.

We must innovate in how we develop and preserve human capital. We must innovate in financing, in balancing the budgeted and business components of the economy. We remain biased toward the former, but don't upset the balance. What that means is we always preserve the vitality of science in the budgeted sector, mainly in the universities. We have to design a strategic program for international collaboration rather than build a hodgepodge of specific opportunities. And we will also need innovations in science-related institutions that overcome those vertical structural relationships that once did have a role, but that today limit mutual empowerment among varied components of the system, and delay decision-making.

And all that must be achieved without surrendering social ownership of the scientific impulse and of what it produces. Social ownership guarantees sovereignty and is intrinsic to socialism. We can do it, and the people know it.

Notes:

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Tom Whitney, a member of the Let Cuba Live Committee of Maine, edited this translation of Agustín Lage's article, obtained from the translation service available at: https://www.deepl.com/home.