Brazil aims for its science to have greater impact

After a period of expansion, Brazilian science is shifting emphasis from quantity to quality, with an eye toward reaping benefits for society.

"We have a large-scale footprint," Celso Pinto de Melo says of his country's research community. "We have scientists in a very broad spectrum of fields—health, biology, physics, chemistry, nanoscience . . . ." In the past decade or so, the number of peer-reviewed papers from Brazil has soared from less than 1% of the world's total to 2.7% last year. "We are in the thirteenth position of absolute numbers of papers published," boasts Melo, president of the Brazilian Physical Society and a professor at the Federal University of Pernambuco (UFPE) in the northeastern part of the country.

Brazil confers around 11 000 PhDs each year, up from 1000 in the late 1980s; in physics, the number went from 134 in 1996 to 234 in 2008. Over the past decade, the Ministry of Science and Technology's budget increased every year, a total of sixfold to R$6.5 billion ($4.1 billion) not including personnel costs. The country's first strategic plan for science, technology, and innovation ran from 2007 through 2010, with funding for that period at R$41.2 billion. Brazil's flagship scientific facility is a synchrotron light source that opened in 1997, for which a R$500 million upgrade is planned. The country is in the process of joining CERN and the European Southern Observatory, and has an ambitious set of S&T goals (see the table on page 28).

The enormous growth is due to support of education and science by the national and state governments, especially since the stabilization of the economy in 1995. "The most important problem that we face as a nation is social inequality," says Melo, but he notes that now "97% of kids ages 7 to 14 go to school. It's the first time in Brazilian history that we have reached full coverage of basic education." Neighboring countries achieved that a century or more ago, he adds.

The current government, which came in at the start of this year, has cut budgets across the board. Science and technology will be down about 9% compared with last year. But, says Sergio Rezende, S&T minister under Luiz Inácio Lula da Silva, Brazil's president from 2003 through 2010, "the government has assured us that no program will be discontinued. Some will not expand." Belita Koiller, a condensed-matter theorist at the Federal University of Rio de Janeiro (UFRJ), says, "We are still happy with the tail of the big investment. We will have to wait and see. It's easier to keep momentum than to have to start again."

Despite current spending cuts, in the new government's economic plan "innovation will be much more central than it was formerly," says Ronaldo Mota, who is in his third year as secretary for technological development and innovation in the S&T Ministry. The new plan "will be more closely associated with international competitiveness and how to establish bridges to connect our science and technology sectors with enterprise and social demand." That, Mota says, means that "physics, as well as engineering, are very special players for the Brazilian present and future." Now the buzzwords in the research scene are impact, innovation, and internationalization. "Our impact is less than the world average," says Melo. "We need to improve."

New opportunities

"When I started studying physics, you could count the number of PhD physicists [in Brazil] on one hand," says Moysés Nussenzveig, who earned his PhD in 1957 at the University of São Paulo (USP) and today works with optical tweezers at UFRJ's Physics Institute. The Brazilian Physical Society now has about 6000 members. For a long time, notes Nussenzveig, the strength of the physics community in Brazil—as in many developing countries, where getting money and equipment is tough—was in theory. Now, he says, "it is not quite the balance of the United States, but it is about 50-50 theorists and experimenters. I have seen a lot of change."

Established in 1934, USP is among the country's oldest universities. Academia really took hold in the 1960s and 1970s, with the founding of many campuses. In the past decade the number of federal university campuses swelled, with inevitable growing pains, from 43 to 230. Some of the new campuses are independent, but many are branches of preexisting universities. Many are inland, bringing higher education to previously unserved parts of the country. In earlier times, "nobody could have dreamt you could be a physicist in the middle of the Amazon," says Melo. "Now we have that opportunity."

The boom in universities means jobs in academia are plentiful. So much so that fresh PhDs are being snapped up, especially by the new campuses, and faculty are having a hard time hiring postdocs. Theo Pavan is doing a postdoc at USP–Ribeirão Preto to broaden his knowledge of medical physics and to help him "get a position in a good university, not necessarily in one of the new ones." He says his friends who took faculty jobs right out of graduate school

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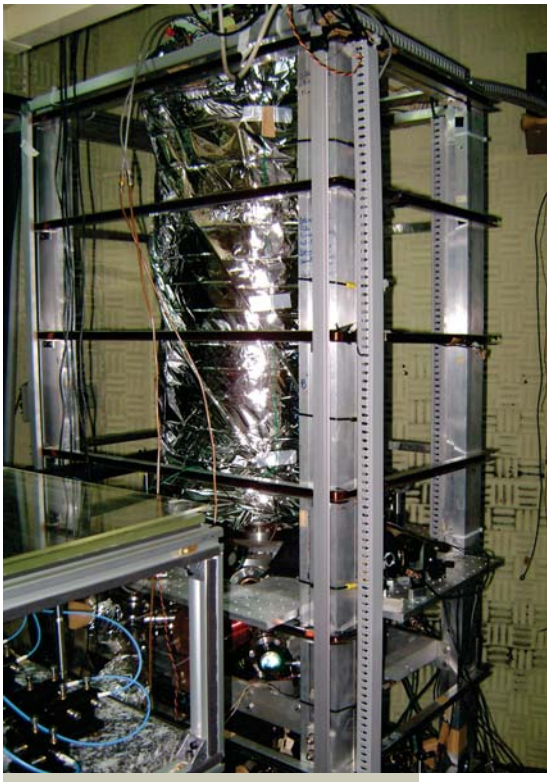

The first atomic fountain in Brazil is used for high-precision spectroscopy experiments and other studies requiring an atomic clock.

LNLS/NATIONAL RESEARCH CENTER IN ENERGY AND MATERIALS

A synchrotron light source in Campinas, São Paulo, is the country's largest scientific facility. Some 2700 researchers from 19 countries used the facility in 2010; 83% of the users were from Brazil, and 15% came from other countries in Latin America. Plans to upgrade the synchrotron are in the works.

feel "pressure to publish, teach, and do research. In the new university campuses, one can find no structure yet, not even in a neighbor's lab. It's not easy."

Some graduates want to get a job right away, instead of maturing as researchers in a postdoc, says Daniel Felinto, whose research at UFPE centers on quantum information and ultrafast science. "Maybe they think the jobs won't be available later. So they get the workload right away, and it's hard to mature with the workload."

These days, continues Felinto, "in many departments, like mine, nobody complains about a lack of funding. Our attention has moved to other problems." For example, he says, "We typically teach two courses per semester, and there are a lot of administrative duties. You have to do education, basic science. There is no time to do innovation."

Scientific engine

The state of São Paulo is the scientific engine that the rest of the country wants to emulate. About half the papers that originate in Brazil and are published in international journals are from people in São Paulo's universities. The state has a strong university system and a culture of spinoff companies that is growing faster than elsewhere in Brazil. The vibrancy of research can be traced to strong financial and political support.

The São Paulo Research Foundation (FAPESP) was started in 1962 and gets 1% of all state revenues, or about $550 million a year. "We have built up an endowment and are very stable," says FAPESP scientific director Carlos Henrique de Brito Cruz. The foundation, he says, provides about half the government research money within São Paulo, with the other half coming from federal agencies. Although some of Brazil's 26 other states have laws on the books to feed the coffers of a state research agency, none has an agency with near the wealth or stability of FAPESP. Moreover, in the state of São Paulo, government spending on research is outpaced by industrial investments.

"Since about 2006 we have seen an important increase in international opportunities," says Brito Cruz. These days he spends more than a third of his time "talking to foreign delegates and organizing partnerships—with Germany, the UK, Denmark, Argentina, Portugal, the US." The combination of Brazil's growing science community and healthy economy, he says, "added up to generate interest from outside the country. At the research foundation, we noticed it was necessary to work proactively to develop those interactions. In science, Brazil was looking inside too much."

"We need teams"

At both the federal and state levels, initiatives are being launched to get scientists to look outward. Among them are an increase in the number of fellowships for students and senior investigators to study abroad for up to a year and for students from other countries to spend time in Brazil. FAPESP requires São Paulo universities to advertise internationally for postdocs. And now a

Ministry of Science and Technology goals to reach by Brazil's 2022 bicentennial

- Increase investments in R&D to 2% of gross domestic product, with more than half from private enterprise
- Double to 340 000 the number of scholarships awarded annually by the ministries of Science and Technology and Education
- Grow the research community to 450 000, or 2 researchers per 1000 inhabitants, up from the current 8 per 10 000
- Generate 5% of the world's production of scientific papers
- Triple the percentage of higher-education graduates in engineering to 15%
- Master the technologies of microelectronics, pharmaceutical production, nanotechnology, biotechnology, and a host of green technologies
- Increase by 10-fold the number of innovative companies, from 3% of industrial companies to 30%
- Increase by a factor of 10 or more the number of patents a year, to at least 4000
- Ensure independence in the production of nuclear fuel and reactor technologies
- Master the manufacturing technologies of satellites and launch vehicles

doctoral thesis can be written in English if the candidate's committee includes a non-Brazilian. "There is an emphasis on increasing collaborations with the whole world, and particularly with our neighbors in Latin America," says the UFRJ's Koiller.

To free up scientists' time for science, FAPESP, for example, has extended grants from four to five years. And, Brito Cruz notes, FAPESP awards money to individual researchers, not to their institutions. "This was important when universities began," he says, because they "were very hierarchical, and older professors controlled everything. But they were not the best, so FAPESP created some subversion by funding the best people directly."

In the past couple of years, the country has invested about $400 million to create 130 National Institutes of Science and Technology around the country. About half of those virtual institutes focus on physics-related research, including 10 in nanotechnology. "The idea," says Mota, "is to stimulate new ways to produce science." Traditionally in Brazil, he says, people worked on their own or in small groups. "Today's problems are more complex. They can hardly be approached by just one line of research. We need teams."

Another boon for research, says Koiller, has been the electronic access to journals that was negotiated in 2000 for all universities. More than 15 000 journals are available in more than 300 institutions, she says. "That has had a big impact." The emphasis in research has shifted from quantity of papers to "a trend to enhance the quality." Right now, says former S&T minister Rezende, "because of Brazil's economic expansion, industry and academia are attracting people from other places." It is key, he adds, for people "to become more ambitious scientifically, and not be afraid to enter challenging fields."

Transforming science for society

Even with increased scientific activity in Brazil, the number of patents remains low, at about 400 a year. In São Paulo, the percentage of researchers working in companies is 60%, but nationwide it fell from 35% in 2006 to 26% last year; for PhD researchers it's less than 5%, according to Rezende. Industry tends to import technologies from other countries rather than create and develop its own, he and others say.

A 2005 law opened the way for the government to provide fiscal incentives for industry—including large companies—to engage in R&D. In addition, a funding line modeled on the Small Business Innovation Research program in the US has been created. Some R$2 billion–R$3 billion is available annually in low-interest loans to stimulate industry. The federal government will pay part of the salary when a company hires a PhD researcher. And researchers can take extended leaves from their university jobs to work in industry. Vanderlei Bagnato, who works in atomic physics at USP, currently heads his university's agency for innovation. He says, "We always had the idea that science should be transformed to benefits for society. But there have always been some missing elements. That's changing."

Under Brazilian law, universities get money from companies for research related to offshore drilling, biofuels, and other areas in which Brazilian industry has been successful. The government is introducing many incentives for innovation, says Nussenzveig, "but by far the biggest challenge is a lack of entrepreneurial mentality. All of science has the problem that there are not enough spin-offs." Alberto Guimarães of the Brazilian Center for Physics Research in Rio de Janeiro agrees: "We have learned how to do science, but we have not learned how to transform science into products."

Brain drain is low, and the country is becoming increasingly attractive to foreign researchers. To those considering coming to Brazil, Guimarães says, "The overall trend is positive. If you come here, you will not be frustrated. Your work would be visible, you could make a difference. If you need large facilities, you can collaborate with other countries. Here, there is a general expectation that things will be better next year."

Toni Feder

Will industry save academic research?

Partnerships with universities could bolster the competitiveness of US corporations.

As funding from their state governments plummets, and with little or no growth likely in the federal R&D programs that pay for most of the research they perform, US research universities are looking to industry for support. University officials are hopeful that US corporations, which perform little basic research of their own and are mostly flush with profits, can be wooed into research partnerships that will benefit both.

Public research universities nationwide have been squeezed hard; appropriations from state governments have plunged an average of 20% in inflation-adjusted terms from 1989 through 2009, according to the Association of Public and Land-grant Universities. Nearly a third of that decline occurred in 2008 and 2009. The University of California's 10 campuses have lost more than one-quarter of their state funding during the past four years. The federal funding picture is little better; the appropriations process to date for the fiscal year beginning 1 October 2011 has R&D budgets that stay even with the current fiscal year, which in turn were essentially the same as FY 2010. That's a far cry from the doubling of funding that