

Pesquisa

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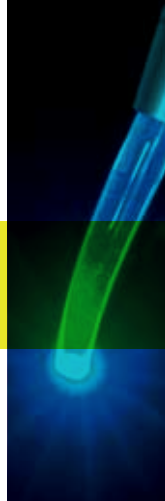
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PESQUISA FAPESP Rua Joaquim Antunes, nº 727,

10º andar, CEP 05415-012, Pinheiros, São Paulo-SP

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LETTER FROM THE EDITOR

Identity and Zika in Latin America

Alexandra Ozorio de Almeida | EDITOR IN CHIEF

A pioneering program that supports technology companies in Brazil celebrated its 20th year in 2017. The Technological Innovation in Small Businesses (PIPE) program, run by the São Paulo Research Foundation (FAPESP), has backed more than 1,700 projects and invested over R\$360 million in 1,100 small and medium-sized companies that want to convert scientific knowledge into new products and services. This international issue features a collection of reports from between May and August 2017, and the cover article (*page 4*) tells the story of PIPE, which was inspired by the US Small Business Innovation Research (SBIR) program.

It is only natural that Brazil, a world leader in sugarcane farming, devotes much of its scientific and technological research to the plant. In 2017, the Sugarcane Technology Center (CTC) in the state of São Paulo developed a transgenic sugarcane that is resistant to the crop's most damaging pest, the sugarcane borer (*page 53*). The variety was recently approved for use by CNTBIO, the national body responsible for assessing the biosafety of genetically modified organisms in Brazil.

As researchers from the human and social sciences have begun working more closely with computer scientists, a new interdisciplinary field, known as digital humanities, has emerged. The collaboration is a two-way street: for social scientists, huge databases of economic and social information, as well as the digitization of art and history collections, have broadened potential lines of research; computer scientists, mean-

while, are tackling the challenge of creating tools to meet the demands of the humanities. This new field also involves studying the role of digital technology in society. One of its most interesting characteristics, described in a report on *page 60*, is how researchers have incorporated tools and concepts from other fields into their activities.

Two articles published in the journal *Nature* describe the results found by two different research groups with separate resources working in parallel to monitor the evolution of the Zika virus genome (*page 34*). With the shared goals of understanding the recent epidemic, predicting future outbreaks, and developing methods of diagnosis, the research combined epidemiological and genetic data to show that Zika spread silently throughout the Americas for at least a year before it was considered a danger to public health. One of the studies used a mobile laboratory and portable genetic sequencing technology to search for clues about the path the virus has taken through Brazil since its suspected arrival in the country in February 2014.

Latin America is the theme of an interview with historian Maria Ligia Prado, who has been studying the region's history and interpretations of its development for almost five decades (*page 10*). She believes that the identity of Latin America, with which the region has grappled since independence, is a sensitive issue. The construction of an identity often disregards our differences and diversity, leading us to see the "other" as an enemy. For Prado, the remedy is a critical spirit.

COVER

PIPE 20 years

With an innovation project contracted every business day, the FAPESP program gave a boost to more than 1,100 small and medium-sized technology companies

Fabício Marques

PUBLISHED IN JULY 2017

A milestone in support for technological companies in Brazil was celebrated in São Paulo at the end of June, 2017. FAPESP's Innovative Research in Small Businesses Program (PIPE) celebrated its 20th anniversary, with 1,788 projects contracted and an investment of more than R\$360 million. The PIPE program provides support to entrepreneurs who want to transform knowledge into new products or services and frequently promotes innovation at a crucial high-risk stage at the beginning. Every three months, a new public notice is issued by the Foundation, in search of projects that are in the initial phases of technological development.

Phase 1 covers research proposals at the initial stage. This phase is focused on demonstrating the technical and commercial viability of innovations that emerge from work done to solve a research problem. In this phase, the funding limit is R\$200,000 for up to nine months. In Phase 2, which lasts up to two years, the research proposal itself is developed, which may include, for example, building a prototype, and up to R\$1 million is offered for each initiative. The objective of Phase 3, in which FAPESP participates with partners (so far only with the Brazilian Innovation Agency (Finep)), is the final development of innovation and the pioneering offer for sale. "PIPE is the largest startup support program in Brazil. It brings together innovation and a meritocracy and created an enormous aquarium that investors want to fish in, according to technicians from the Brazilian Development Bank (BNDES) who visited us

recently,” says José Goldemberg, president of FAPESP, at an event held to commemorate the program’s anniversary on June 30, 2017.

In 2016, the program invested R\$56,000,000 and contracted 228 projects, the largest number ever (see the chart on page 6). “An innovative project was contracted almost every business day,” notes Carlos Henrique de Brito Cruz, scientific director of FAPESP, who highlights the efforts of the Foundation to expand the program despite the financial crisis affecting Brazil and its impact on FAPESP’s budget. PIPE has already supported companies in 125 municipalities in São Paulo State, but most are concentrated in cities such as São Paulo, Campinas, São Carlos, São José dos Campos and Ribeirão Preto, home to major universities and research institutions. “Technology-based innovation naturally arises around good research institutions,” says Brito Cruz.

Among the more than 1,100 companies with approved proposals, one of the most successful cases is that of Griaule. Established in 2002 in an incubator at the University of Campinas (Unicamp), Griaule developed algorithms and software programs for fingerprint recognition, such as those used in electronic voting machines in Brazil, in addition to voice and human face identification systems. The firm was the recipient of three PIPE projects. “They accelerated our growth. With the project-related research grants, we were able to bring together the critical mass to improve the algorithms that are our comparative advantage,” says Alexandre Creto, project manager at Griaule. Two researchers who were grant recipients in the most recent PIPE program, concluded in 2011, were hired and are still at Griaule today. The company, which began with five people in 2003 and with sales of R\$100,000, has 40 employees today, half of whom are working in research and development (R&D), and had 2016 sales of R\$40,000,000.

Another successful example is Promip Manejo Integrado de Pragas, headquartered in Limeira, which had a PIPE project approved in 2006 when it was installed at the incubator of the Luiz de Queiroz College of Agriculture of the University of São Paulo (ESALQ-USP). This research led to two biological products containing predatory mites that can control the two-spotted spider mite, a pest that attacks salad greens. “This was not a simple challenge. The biologic product did not exist, and the farmers did not understand how it could be important in reducing chemical in-



Apis Flora, from Ribeirão Preto, developed a dry propolis extract that is used as a raw material for medications

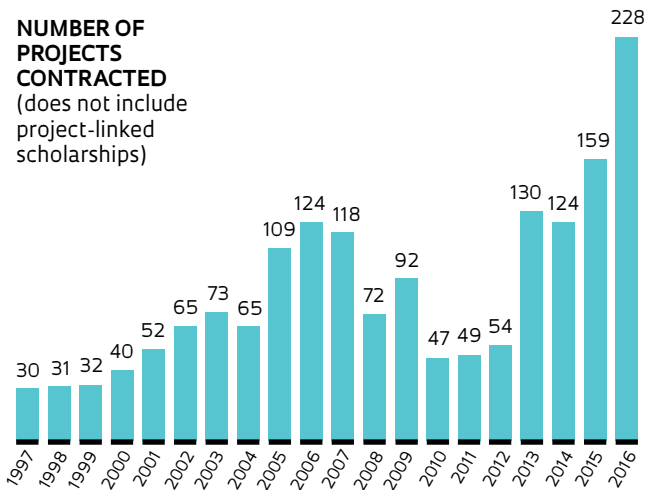
secticide use,” remembers Marcelo Poletti, who founded the company with two partners after finishing his doctorate in entomology at ESALQ. Other PIPE projects helped create products based on different types of predator insects and mites and to develop kits to monitor the resistance of *Aedes aegypti* mosquitos to chemical insecticides. Today, Griaule invests 8% of its revenues in R&D. With 100 collaborators, it had sales of R\$10,000,000 in 2016.

Promip sells five products and has another five under development. In 2014, its innovative profile earned the company a contribution of R\$4,000,000 from the São Paulo Innovation Fund, established by the Desenvolve São Paulo agency, in partnership with FAPESP, Finep, the Development Bank of Latin America (CAF), the Brazilian Micro and Small Business Support Service (Sebrae), and private investors. “FAPESP invested R\$10,000,000 in the fund to be allocated to daughter-companies of the PIPE program,” explains Francisco Jardim, manager of the São Paulo Innovation Fund. “We participated very enthusiastically, because there are businesses with a strong capacity to systematically promote innovation. We are preparing to double our bets in some of them.” Other clients of the PIPE program, such as Nexxto and Inprehnha Biotecnologia, received support from the fund. “The PIPE program, with its rigorous evaluation of proposals, and the manner in which it guides entrepreneurs, fills an important void. The funds can help startups to compete in the market and solve management problems, but they cannot do a good job evaluating the potential of research that could lead to innovations,” he affirms. According to Jardim,

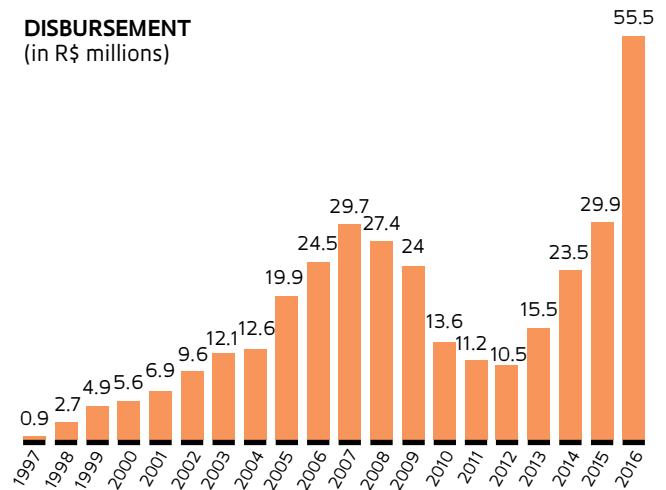
A leap forward in support for innovation

Yearly trend in the number of PIPE projects contracted and FAPESP disbursements under the program from 1997 to 2016

NUMBER OF PROJECTS CONTRACTED
(does not include project-linked scholarships)



DISBURSEMENT
(in R\$ millions)



SOURCE FAPESP

the fund has encouraged other companies that it supported, such as InCeres in the precision agriculture field and Ventrix in the health care area, to present projects to the PIPE program. “The capacity to carry out R&D internally multiplies the chances of a startup’s survival.”

The Pitanga Fund, established in 2011 with R\$100,000,000 in funding from Brazilian business executives from groups such as Natura and Itaú, spent two years analyzing 700 candidates for a grant. In 2013, it chose the first startup in its investment portfolio, I.Systems, founded in Campinas 10 years ago by four computer engineers from Unicamp. This startup provides major clients, such as Coca-Cola, Braskem, Ambev, Suzano and Raízen, with software that uses artificial intelligence to control industrial processes. Its programs are able to monitor a large volume of data and make decisions that reduce production costs by 2% to 10%. According to company president Igor Santiago, two PIPE projects, approved in 2009 and in 2012, were important for development of the first prototype, the Horus program, and for bringing the technology to market. “It would have taken a long time if we would have had to depend on our own funding,” he affirms. In 2015, the company received support from PIPE to develop a new product, called Leaf Captação, in the basic sanitation area: it controls the flow of water catchment pumps from rivers to supply cities, rationalizing energy consumption. I.Systems’ flagship product is a type of software program that was initially not thought to be very important, called Leaf for Windows, which runs on large computers used by industries. I.Systems has doubled its size every year in the past four years.

An evaluation of 214 PIPE projects developed between 1997 and 2006, conducted by the Study Group on Organization of Research and Innovation (Geopi), affiliated with Unicamp, showed that the program had an impact on several fronts (see *Pesquisa FAPESP Issue No. 147*). Approximately 60% of the projects evaluated led to technological innovations, a rate considered satisfactory. This represents 111 innovations, 59 of which are considered innovations in Brazil and 17 are viewed as such from a global perspective. “These were technology-based innovations, in line with the purpose of the program,” says Sérgio Salles-Filho, professor at Unicamp and one of the coordinators of the Geopi. These projects helped to create high-level jobs: at the companies evaluated, the increase in the number of employees with college degrees was 60%, and the increase for professionals with doctoral degrees was 91%. An article published in 2011 in the journal *Research Evaluation*, whose principal author was Salles-Filho, showed that each R\$1 allocated by FAPESP to the program generated a return of R\$10.50. A more recent evaluation, based on the period from 2007 to 2016, is being conducted by Geopi, comparing the results of the projects with those from programs in countries such as the United States, France and Japan. “The PIPE program will also begin to be monitored continuously, with data collected both after the end of the project and two years later,” affirms Salles-Filho.

ANGEL INVESTORS

XMobots, in São Carlos, which manufactures unmanned aerial vehicles (drones), with sales of more than R\$7 million a year, was able to build

its first drone for testing after approval of a PIPE Phase 1 project in 2009. “Until then, we depended on equipment borrowed from USP laboratories in São Paulo in order to work,” says engineer Giovanni Amianti, one of the founders. “Support from the PIPE program showed that our idea had potential. In other countries, angel investors play this role, helping to transform a good idea from the academic world into an emerging business,” notes Amianti, whose company now sells three types of drones and employs 40 people, 10 of whom are engineers on the R&D team.

Gustavo Pagotto Simões, president of Nanox, a startup in São Carlos that produces microparticles with bactericidal properties, calls attention to an unusual characteristic of the PIPE program: with four invitations issued per year, this FAPESP initiative has become an anchor for entrepreneurs in the state. “Whenever we needed to, there was an opportunity to submit a proposal to the PIPE. This regularity is not as common in other sources of funding,” acknowledges Simões, who has already received funds from Finep, BNDES, Sebrae and the National Council for Scientific and Technological Development (CNPq). Nanox had a dozen PIPE projects, but two of them were more important than the others. “The first, in 2005, was vital: that R\$70,000 enabled us to test our technology with clients,” says Simões, who opened the business with two colleagues from his graduate studies at São Paulo State University (Unesp), in Araraquara. In 2006, Nanox received support from the Novarum Fund. Its growth accelerated: in 2010, its sales were R\$2,300,000, compared to R\$1,300,000 just one year earlier in 2009.

The other major project came in 2012, when Nanox already produced 2 to 3 kilos of silver microparticles per day and wanted to multiply the operation by a factor of 10. “FAPESP and Finep issued a call for proposals for Phase 3 of the PIPE, and thanks to it, we were able to increase our

According to the evaluation, each R\$1 allocated by FAPESP to the program generated a return of R\$10.50

production capacity and manufacture 20 kilos of microparticles per day,” says Simões – current production is 60 kilos a day. Today, silver additives are used in milk boxes, PVC films, and dental instruments.

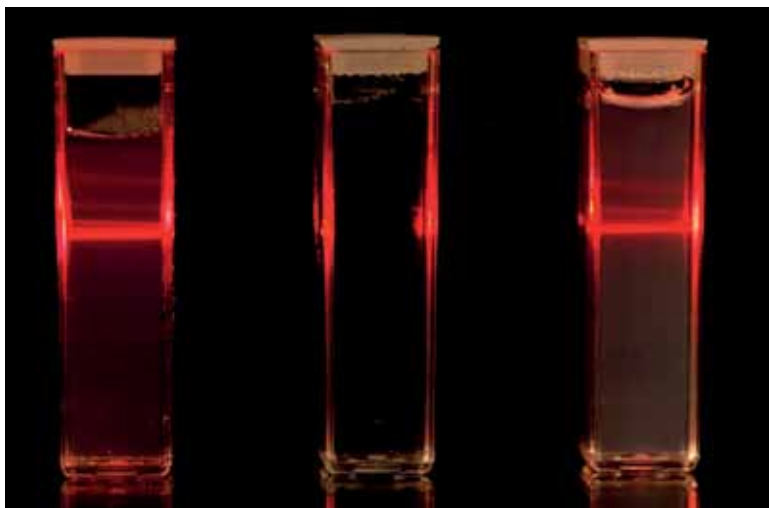
Several beneficiaries of the PIPE program have greatly increased their sales, but this is not the only measure of the program’s success. According to Sérgio Queiroz, professor at Unicamp and adjunct coordinator of the FAPESP Research for Innovation area, there are indirect benefits from the implementation of a culture of innovation at companies. One example of this is Apis Flora in Ribeirão Preto, which specializes in products and medications made from honey and propolis. Founded in 1983, in the last 10 years, the company reinforced its R&D structure in search of innovative products. The first PIPE funding was

approved in 2009 to develop a cellulose biomembrane, which, associated with propolis, could be applied to hard-to-heal wounds. “My doctoral work had demonstrated that this material is useful in the treatment of burns,” recalls Andresa Berretta e Silva, R&D and innovation manager at Apis Flora. In 2010, a project proposal sought to obtain a propolis-based gel to fight vaginal candidiasis. “With this project, our biotechnology laboratory took a giant step forward.”

Investments made beginning in 2009 have led to five innovative products, four of which are medications that have not yet reached the market. Even so, Apis Flora’s sales grew from R\$7,000,000 ten years ago to R\$38,000,000 in 2017. One of the reasons for this performance was the capacity developed by the company to produce a propolis extract in the form of microparticles, used as a raw material for medications. This capability, developed in research financed by CNPq, enabled the company to export the ingredient to China and made the difference in its sales. Another result of this work was the creation of a startup, Eleve Pesquisa e Desenvolvimento, incubated at Apis Flora. The new firm already has two approved PIPE projects focused on developing a medication against leishmaniosis and a model for a kind of skin that would eliminate the need to use animals in cosmetics testing.

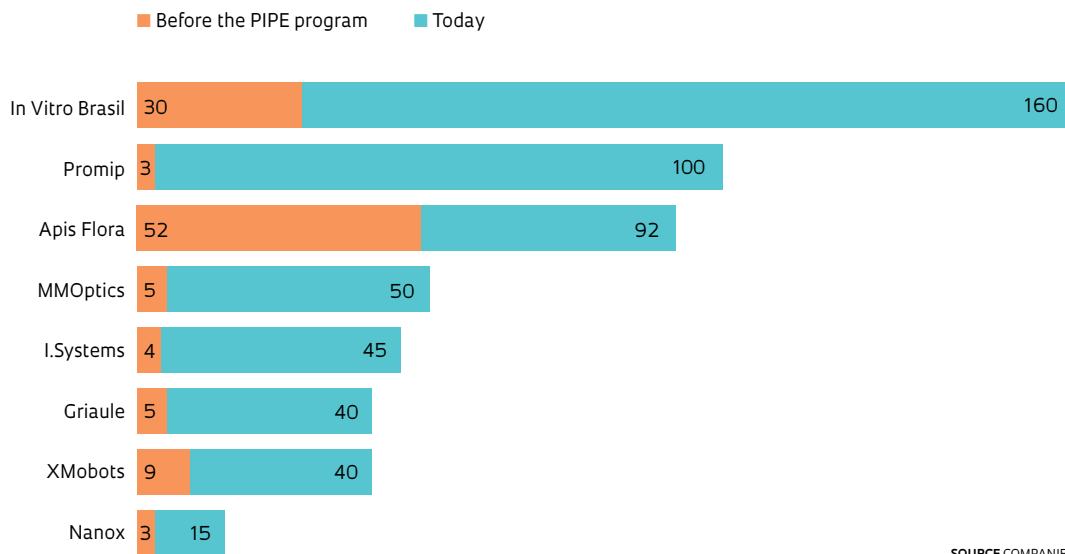
In Vitro Brasil, a company in Mogi Mirim, multiplied its sales after it began to invest in R&D, to the point of being responsible for over half the world’s production of *in vitro* bovine embryos. In 2015, it was purchased by the U.S. company ABS Global, the largest bull genetics company in the world. In Vitro was founded in 2002, but it took several years before it began to produce innova-

Microparticle compounds produced by Nanox in São Carlos



Job creation

Number of employees at the time of the first PIPE project, and current number, for selected companies



SOURCE COMPANIES

tions. According to Andrea Basso, the company's research coordinator, two PIPE projects resulted in approaches that are innovative in terms of the international market. One of them showed that it was feasible to produce embryos using calves instead of adult cows, with egg harvesting done by videolaparoscopy after hormonal stimulation. The other project developed a method of genetic analysis that made it possible to select embryos before they were transferred into the brood cows. "Until then, genotyping was used in the selection of newborn animals to be used as breeders. What we proposed was to genetically evaluate a sample of embryo cells, freeze them and, after concluding analysis, chose which animal would be born," says Basso. Today, the company has more than 160 employees, compared to 30 employees 10 years ago. It has built a network of 33 laboratory units that produced 450,000 embryos in 2016. Its 2016 sales were R\$28,000,000, a hundred times greater than those in 2007. In Vitro Brasil created a startup, In Vitro Brasil Clonagem Animal, which remains a Brazilian company, with Basso being one of the partners. It has just been accepted for a PIPE Phase 1 project for production of a protein that plays a key role in blood coagulation.

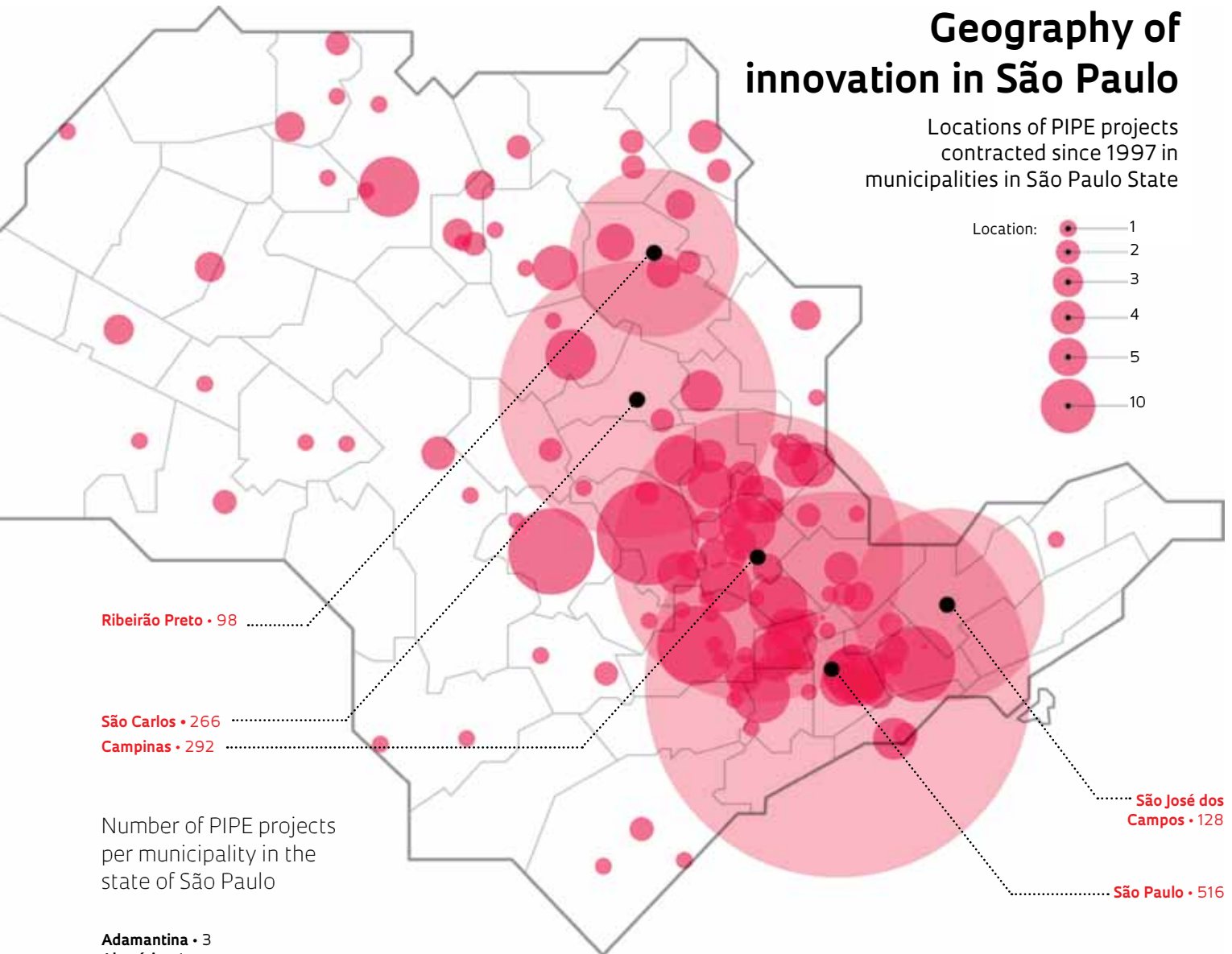
PIPE was the first funding modality in Brazil to invest non-reimbursable funds in research at companies. "With the passage of the Innovation Act of 2004, other agencies began to allocate money to non-recoverable loans in innovation in the private sector. But in 1997, that was almost a taboo, and we faced a great deal of resistance against

implementing the program," physicist José Fernando Perez recalls. He was scientific director of FAPESP when the program was launched. According to Perez, the PIPE program was inspired by the SBIR (Small Business Innovation Research) programs run by U.S. funding agencies that had a budget in excess of \$100,000,000. "When we learned about the SBIR programs, we saw that they were a good fit for what we wanted to implement at FAPESP, with the research being done within the company, resulting in an innovative product, process or service," affirms Perez. One of the arguments against the program, he says, was that the scarcity of candidates would make the initiative a fiasco. However, the decision was made to take that risk, and in the first call for proposals, there were 79 submissions, 30 of which were selected.

In the past five years, the program has picked up speed, becoming less restrictive about the size of companies—it is possible to submit a proposal even before a company is founded and to formalize its formation later. Whenever it issues a new invitation, FAPESP holds an event to answer questions from interested parties, known as Dialogue on Research Support for Innovation in Small Companies. "The event has been important in letting proponents know exactly what the program is and ensuring the high quality of the proposals presented," says Sérgio Queiroz. On July 29, 2017, the day before the commemoration of PIPE's 20th anniversary, the FAPESP auditorium was full of entrepreneurs interested in the next call for proposals. ■

Geography of innovation in São Paulo

Locations of PIPE projects contracted since 1997 in municipalities in São Paulo State



Number of PIPE projects per municipality in the state of São Paulo

- Adamantina • 3
- Alumínio • 1
- Americana • 4
- Américo de Campos • 1
- Amparo • 2
- Analândia • 2
- Angatuba • 1
- Araçariguama • 1
- Araçatuba • 3
- Araraquara • 9
- Araras • 5
- Ariranha • 2
- Artur Nogueira • 2
- Arujá • 2
- Assis • 2
- Atibaia • 2
- Barretos • 2
- Barueri • 9
- Batatais • 3
- Bauru • 4
- Boituva • 1
- Bom Jesus dos Perdões • 3
- Botucatu • 26
- Bragança Paulista • 4
- Caieiras • 1
- Cajamar • 7
- Cajobi • 3
- Campinas • 292**
- Capivari • 3

- Carapicuíba • 2
- Cajati • 1
- Catanduva • 3
- Charqueada • 2
- Cotia • 13
- Cravinhos • 4
- Diadema • 9
- Dois Córregos • 2
- Engenheiro Coelho • 4
- Estiva Gerbi • 1
- Ferraz de Vasconcelos • 2
- Franca • 4
- Francisco Morato • 2
- Franco da Rocha • 1
- Garça • 1
- Guararema • 2
- Guaratinguetá • 1
- Guarujá • 2
- Guarulhos • 5
- Holambra • 8
- Hortolândia • 1
- Ibiúna • 1
- Ilha Comprida • 1
- Ilha Solteira • 1

- Indaiatuba • 9
- Itapeperica da Serra • 1
- Itapetininga • 2
- Itapeva • 1
- Itapira • 7
- Itararé • 1
- Itu • 1
- Itupeva • 1
- Jaboticabal • 7
- Jaguariúna • 2
- Jandira • 1
- Jarinu • 1
- Jundiaí • 12
- Juquitiba • 1
- Lençóis Paulista • 1
- Limeira • 8
- Mairinque • 1
- Marília • 1
- Matão • 1
- Mauá • 4
- Mirassol • 1
- Mococa • 3
- Mogi das Cruzes • 20
- Mogi Guaçu • 4

- Mogi Mirim • 7
- Monte Alto • 1
- Monte Aprazível • 1
- Monte Mor • 1
- Orlândia • 2
- Osasco • 2
- Palestina • 1
- Patrocínio Paulista • 2
- Paulínia • 11
- Pindorama • 1
- Piracicaba • 37
- Pirassununga • 6
- Poá • 4
- Porto Feliz • 1
- Rafard • 6
- Rancharia • 1
- Registro • 2
- Ribeirão Pires • 3
- Ribeirão Preto • 98**
- Rio Claro • 9
- Riolândia • 2
- Salto • 1
- Santa Bárbara d'Oeste • 3
- Santa Maria da Serra • 1

- Santana de Parnaíba • 10
- Santo André • 8
- Santos • 6
- São Bernardo do Campo • 7
- São Caetano do Sul • 13
- São Carlos • 266**
- São João da Boa Vista • 1
- Patrocínio Paulista • 2
- São José do Rio Preto • 13
- São José dos Campos • 128**
- São Manuel • 1
- São Paulo • 516**
- São Roque • 5
- Serrana • 2
- Sertãozinho • 5
- Socorro • 1
- Sorocaba • 22
- Sumaré • 4
- Suzano • 1
- Taboão da Serra • 2
- Tupã • 1
- Valinhos • 3
- Vista Alegre do Alto • 1
- Votuporanga • 3

SOURCE: FAPESP

Unanswered questions in Latin America

The historian talks about identity, wars of independence and interpretations of the region's development

Glenda Mezarobba | PORTRAIT Léo Ramos Chaves | PUBLISHED IN JULY 2017

Maria Ligia Coelho Prado already had three children when she decided at 27 to study history at the University of São Paulo (USP). Although she entered the field late in the game, the choice would prove to be right on the mark: in addition to being “love at first sight,” it led her to teaching, which she would practice at a level matched by few of her peers. Prado taught in public and private high schools, and in the 1980s, she crisscrossed the State of São Paulo, teaching the history of the Americas to high school teachers. Before being hired by the USP School of Philosophy, Literature and Human Sciences (FFLCH), she began her career at the university level as a professor of contemporary history for architects-in-training.

In her classroom, Prado tackled big topics, such as slavery, capitalism and interpretations of Latin American development. Along with the usual reading list, her habit was to assign her students labor contracts, worker manifestos and political party platforms. She ignored borders, and in response to invitations from American universities, she taught eight courses in the United States be-

tween 1987 and 1995: three at the undergraduate level and five at the graduate level at institutions such as Brown, Stanford and New York University.

Prado trained generations of professionals at the undergraduate and graduate levels and formed close friendships in the process. One close friend was another historian, Maria Helena Capelato. ‘We defended our master’s theses on the same day, in front of the same committee, one after the other,’ she recounts. They subsequently co-authored a book, *O bravo matutino* [Troubled Early Morning] (Alfa Omega, 1980), based on research gathered on the newspaper *O Estado de S. Paulo*. Among the books she has published, an educational one, *A formação das nações latino-americanas* [The development of Latin American nations] (Atual, 1985), had 23 editions and sold more than 70,000 copies. She is currently at work on a new book containing already-published articles and unpublished texts, including one on the death penalty’s impact on women considered traitors under the Spanish Crown during the wars for independence, and another on the debate about the role of the state, church and family in public education in Colombia in the late 19th century.

AGE 76

SPECIALTY

Latin American history

EDUCATION

Undergraduate (1971) and master's (1974) degrees in history, doctorate in social history at the University of São Paulo (USP) (1982)

INSTITUTION

USP

SCIENTIFIC PRODUCTION

Author of 15 books (of which five in co-authorship), advisor on 19 master's theses and 32 doctoral dissertations and supervisor of six post-doctoral fellows



A founder of the National Association of Researchers and Professors of the History of the Americas (ANPH-LAC), which she headed between 1998 and 2000, Prado spoke with *Pesquisa FAPESP* about Latin America, identity, the role of historical discourse and the function of knowledge.

How did you become interested in Latin America as a topic of interest?

In my undergraduate coursework in history, there were two subject areas that dealt with the Americas: the history of colonial America and the history of independent America. I completed my undergraduate work in 1971, but I had never studied America after independence – we never got past *caudilhismo* [the authoritarian period]. We were stuck there. As a student, I never studied anything related to Latin America after 1850. Nothing. In 1975, when I began working as a university professor, during the selection process for history of the Americas, I had to give classes on the history of America after independence. My intention was to change direction because my research was on Brazilian history. I am self-taught in Latin American history – I began to study it with no background whatsoever. And it fascinated me.

What prompted this fascination?

One example: the history of Mexico, the world of indigenous peoples and how the Mexican state was formed. We really don't know anything about the indigenous communities in Mexico, Peru, Bolivia or Guatemala. Or about the liberal reforms in Mexico, and later in the rest of Spanish America, which involved an attempt to destroy indigenous communities. The culture, the issues of language, of art, the role of the Catholic Church. And the conflicts between the secular and religious worlds.

For your further development of different historical issues – is Latin America always your prism?

Yes. I know the history of a few countries in Latin America, but not all of them, because that would be impossible. I know best the histories of Mexico, Argentina and Chile. When I started teaching, Brazil was a military dictatorship, so Cuba was taboo, you could not talk about it. So it wasn't studied. Latin America was

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Working with
the issue of
identities
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contradictions

where dictatorships thrived. Since I was on the left politically from the very beginning, I opposed the dictatorship. This made the region even more alluring to me. Something which has captivated me from the outset was the historical convergence between Portuguese America and Spanish America. This includes approaches to notions of knowledge, religion and art alongside the specific social relationships that formed in this space, with a significant indigenous and African population.

When does the notion of Latin America first appear? When does the region become known by that name?

This is a very interesting question, because people use the name without really thinking about what it means. The name arises in the 19th century, apparently coined by the French, and it involves a lengthy debate. The economist Michel Chevalier [1806-1879] first made the distinction, common in the 19th century, between Latins and Anglo-Saxons. And, since the French had interests in

the Americas, especially in Mexico, the idea arose that this part of the Americas, which was not Anglo-Saxon, was Latin in its resemblance to France. In publications like the *Revue des deux Mondes* [a French magazine from the 19th century], France is clearly seen as the main Latin country in the world, and as such, this part of the Americas was clearly identified with the French. This is one version of the story, a name that was created outside of the region, with external intentions, which was to some extent imposed.

But there is another perspective, shared by those who understand the term to have in fact arisen in Latin America.

That's correct, there is a debate related to a Colombian writer, Torres Caicedo [1830-1889], who wrote a poem in which he speaks of a Latin America. But the main issue here relates to a problem that is still with us: whether the term was coined outside of the region by an imperialist Europe and then imposed upon us, or whether it arose in Iberian America as a way of unifying us, bringing together Spanish America and, to some degree, Portuguese America, which were facing these uncertainties together. So the term itself is already problematic.

How do you approach the issue of Latin American identity?

I am going to digress a bit here to get to your question. If we look to the writings of scholars, whether intellectuals or politicians – like Simón Bolívar [1783-1830], for example, and his famous 1815 Jamaica Letter, he poses the question: 'Who are we? We are neither Americans nor Europeans.' This search to affirm our identities is very present in these writings and many others that appear throughout the 19th century. I'm bringing this up to highlight that the issue of our identity has been on the table since independence. If we look at the sources from that time, there are documents and actions that demonstrate concern about how the different regions of America colonized by the Spanish will come together, and later in the 20th century, with Brazil.

So, there is always this relationship in play?

Yes, there really is. We have writings from Chilean intellectual and politician Francisco Bilbao [1823-1865] from

the 1850s, in which he describes an America at risk, given that what will be known subsequently as Latin America will have the United States to deal with. This challenge of identity is not something that historians and anthropologists created. It's not a pretend problem from my perspective. That's the reason, as I have already written, that working with the issue of identities needs to involve a certain skepticism, because identities obscure contradictions. They reconcile them.

They almost blend them.

They do. All women are equal, all blacks are equal, all native peoples are equal, to use the conventional terminology of the 19th century, and the contradictions, tensions and conflicts are hidden. Identity, which touches on emotions, is an intellectual construct, but it awakens our hearts, affects our lives and our choices, and forces differences and conflicts to the margins. You need to be very skeptical to work with this issue. Identity always assumes that there is an 'other' – and that the other is the enemy. You must choose. In the case of Latin America, the manufacturing of an enemy in the 19th century points to the United States. There is a key moment – 1898 – when the United States enters Cuba's war of independence in support of the Cubans against the Spanish, which transforms Cuba into a protectorate.

You wrote that since the independence of their respective countries, the Latin American elites have aspired to consolidate their control over society by creating a homogeneous identity that would guarantee them political hegemony. Can we say that to some extent they did not enjoy much success with this in Latin America?

This question does not go away, and it is a tough one to answer. The 19th century is a fascinating period to study, because intellectuals and politicians at the time asked these fundamental questions that we are still wrestling with. What is a nation, what is a civilization, what is legitimacy, what is the State? And their responses established the basis for what a 'civilization' should look like. The con-



With Maria Helena Capelato (at left) in 1980, upon the publication of *O bravo matutino*, which they co-authored

nection between race and culture was a key element in the symbolic domination of the elites, and this connection fed discrimination and prejudice. Albeit manufactured and unreal, this discourse has had a huge impact on Latin American societies up to the present day. The discourse belonging to 'white civilization' imposed its vision on all of society to distance itself from 'the other – barbarian.' So, it has never been possible to control or extinguish *los de abajo*. Native peoples, slaves, people of mixed race, and women made their presence known in politics, art and literature, and resisted the domination imposed by whites. In the end, I believe the elites were successful in their intention to dominate their societies. However, we have to acknowledge the important role played by those who were dominated, because they served as the political opposition, even though they were often overlooked by historians.

In Latin America's recent history, was there a time when the countries of the

region were closer, including as a subject of study?

Yes, they were closer during the recent dictatorships because of political circumstances connected to a unique struggle for democracy. There was a closeness, a shared interest, a deeper knowledge. When democracy arrived, it ended up creating more distance between us. Brazil turned its back once again on Latin America and positioned itself as a distinct country. Brazilian political and diplomatic history clearly points to the fact that Brazil has always wanted to be the dominant country in South America. This has had repercussions in Latin America and on Latin America's place in the study of history. When we ignore Latin America, we lose the possibility of gaining a different perspective on Brazil itself. When we study and follow the history of other countries, we gain a better understanding of many issues in Brazilian history. Historians are quite used to focusing on their own concerns when considering their nation's history, which is still heavily influenced by frameworks developed in the 19th century.

You addressed this issue in your book, América Latina no século XIX: Tramas, telas e textos [Latin America in the 19th Century: Plots, Screens and Texts] (Edusp, 1999).

First, I want to reiterate the importance of seeing Brazil as part of Latin America. Crossing the border opens up intriguing possibilities for the historian who can identify new issues and broaden historical discussions. As you know, in the 19th century after independence, the State is organized and national identity is constructed. From my perspective, the issue of nation comes to the fore and is integrated into the varied political, historical and artistic output of the time; politicians, commentators, historians, educated men and women and artists from across Latin America brought themselves to the task of defining their national identities. In addition to the economic problems, political conflicts, social upheaval and civil wars that mobilized debate in these societies, there were also passionate discussions on nation-building and identity.



Prado's former students (*she is in the middle, in blue*): José Luis Beired (UNESP), Sílvia Miskulin (UMC), Luiz Felipe Moreira (UEM), Kátia Gerab Baggio (UFMG) and Stella Maris Vilardaga (USP)

This takes us back to the idea of transculturation put forth by the Cuban sociologist Fernando Ortiz. Could you comment a bit on this?

In his book, *Cuban Counterpoint: Tobacco and Sugar*, published in 1940, Ortiz [1881-1969], in thinking about Cuban culture, coined the notion of transculturation, which was then appropriated by many literary critics, anthropologists and historians. The concept embodies a very important idea about how to conceive of Latin America that I agree with. For a long time, the prevailing idea was that European culture was imposed on us, on the people who lived here before the Europeans arrived and those who were here during colonial times. European culture was said to have been transposed and imposed here. What remained was merely for Latin America to accept it. Accepting it meant copying it. Ortiz said that this notion – and he is referring to Cuba – of a simple imposition of culture from abroad, even in a society organized around slavery, is inaccurate. In his view, both in Europe and in Latin America, a very special cultural mix was created, and Europeans were not immune to the environment in which they lived, which included African culture. It is a two-way street. Power was involved, and Europe imposed its language and religion, but it's important to understand the relationships that formed on every level, as he says, from economic to sexual. What we

study in that social environment is transculturation, and it involves change and reformulations. I believe it still makes sense to think of it this way.

In your view, can the historical discourse be reduced to a function of knowledge, or does it serve a social function?

If you had asked me this 1975, I would have said that historical discourse cannot be reduced to a function of knowledge and that it does serve a social function, where it has an influence on what is really happening and will be useful to some degree for those in the struggle for social change. Understanding the past creates the conditions for knowing the present and predicting the future. History, then, played a disproportionate role in ideological confrontations, and historians and academics should have understood that their work was not disconnected from their political responsibilities. Today, the public debate is different in nature. Let's take the issue of "School without Party," which is without a doubt grounded in the idea that historical discourse has a social function. This group, which declares itself to be on the right, attacks the left for saddling knowledge with ideological and political aims and in this way affirming that it cannot be neutral. In apparent contradiction, however, it presents itself as indifferent to politics and raises the flag as a defender of a single "truth."

Are there changes in historiography that affect the social function of knowledge?

Particularly during the military dictatorship [1964-1985], we thought that knowledge would set us free, bring us democracy and create the conditions for the construction of a more just society. If we define social function in this way, it is because knowledge and ideas lead to actions. Policy proposals that will be enacted are based on ideas, and in this sense, knowing history is essential. By way of example, let's look at the role of indigenous people in our society. Anthropologists and historians have done work to show how they were exploited, oppressed and humiliated. The same work has been done for the African slaves brought to Brazil. Brazilian historiography, like that of Cuba, has worked hard to turn this conventional approach upside down. Another idea, which your question points to, is that in the case of history, the truth will finally be revealed. Historians are divided when they approach the issue of truth. What is truth? I like to use as an example an event which is somewhat removed from us today: the French Revolution. Consider the people who wrote about it at the time and in the subsequent first or second generations thereafter. How can you write about the French Revolution [1789-1799] without having participated in it? What perspective would an aristocrat like Alexis de Tocqueville [1805-1859] have? And someone on the left of the political spectrum in 19th-century France? There are some facts that are solid and indisputable: the king and queen were guillotined. Now, how do we interpret those facts? That is the question. Can we reduce it to: 'Now I am going to tell you the story of the French Revolution'? What is the truth? This means that we will be interpreting and analyzing documents. We must have a theoretical background to understand the role and the place of that document, what it expresses.

Doesn't history teach us something? Or is it that human beings don't learn the lessons?

I think a lot about this. I am not obsessed with the French Revolution, but I am going to use it as an example again. The French Revolution established that torture should not be legal – human beings cannot be violated. Not exactly in these terms, but for the first time, this declara-

tion appears. Before that, torture was considered completely legal and legitimate. This represents a very important watershed in recent human history, at least in the West. Which does not mean, as we well know, that torture was eliminated.

The role of women in the struggle for independence, for example, which is an important theme in your work, is still relatively unknown. Can you talk a little about your findings?

Women in the 19th and 20th centuries as subjects of historiography are treated as if they did not exist in the political sphere. Much significant work has been done to highlight the role played by women as thought leaders, writers and journalists. What interested me was to look at women's political participation in the 19th century. In general terms, historiography begins by pointing to the presence of women in politics as a function of suffragism, when they began to fight for the right to vote. Though few in number, women were already participating in politics in Brazil and Latin America in the 19th century. I worked from the following premise: why did Maria Quitéria [1792-1853], who lived in inland Bahia State, dress as a man, become a soldier and engage in the fight for Brazilian independence against the Portuguese military led by General Madeira? This is her story: at her father's home, she overheard an emissary who was recruiting volunteers to fight in the war. Since I am always crossing borders in my own head, I thought about Spanish America. After a lot of research and reading of many biographies and newspapers from the time, I discovered that many other women also participated in the wars, especially in Spanish America, because in Brazil, the war of independence lasted only a short time. In Spanish America, over the course of 10 or 12 years of war, women participated in many different ways.

Including taking up arms...

That's right, they took up arms, dressed as soldiers, and many were called 'messengers,' that is, people who infiltrated the other side and played a part, putting themselves at risk. I believe what's significant here is that they were engaged and participated, they didn't stay on the sidelines. Even when you consider the men who were involved, you



Women also participated in wars, especially in Spanish America

must remember that the wars for independence involved a minority of people. Only a small percentage of the population participated. Some believed in the cause, took up arms and headed to battle whether on the winning or losing side; they took the risk. Women were taken prisoner, prosecuted and imprisoned. A well-known case is that of the Colombian Policarpa Salavarrieta [1795-1817], who was executed at the Plaza of Santa Fé in Bogotá. She and seven men, including her fiancé. Her death had a huge impact. There are anonymous artists depicting her in the gallows. Poems and plays were written in her honor. Other women like her were also condemned to death or to public punishment, like having their heads shaved or being forced to parade nude through the city. There are many stories like this, but they are largely minimized or unknown. It is nonetheless a fact: women were involved in politics in Latin America in the 19th century.

In your writings, you also devote a lot of time to thinking about utopias.

It is abundantly clear that my generation, living under military dictatorship, believed that a socialist utopia was on the horizon, and that gave us the strength and hope to face daily life. In the 1980s, the idea of democracy as a foundation was widespread, and it appeared to be something of a utopia for Latin America at that time. Today, we are undergoing

very hard times, involving deep conflict, ideological confrontation, political positions that are often taken under pressure and without consideration of their broader implications. The most striking problem for me is the lack of any utopian idea. At times of extreme challenge and despair, my generation imagined a better future on the horizon – one that in some way would create a more just society, democracy, and less oppression. That's what allowed us at the same time to endure that difficult period and still remain unified. There is so much cynicism today ... Consumerism has overtaken us. It appears we have lost the idea of higher principles that guided many politicians, intellectuals and workers in the 20th century. Everyone thinks in very pragmatic, short-term ways. This is a bit disturbing and even dangerous. We need a plan for the future in order to bear the day's political events. We have to have some kind of horizon. Today, the big umbrella issue that seems to unify people is the environment – environmental issues, nature conservation. This issue moves people, even brings together people with different political beliefs on the left and the right. But I don't see a utopia that inspires us with an idea like 'let's create a world with less poverty and more equality,' a notion that kept us alive during the most challenging moments of our past. I'm not a cynic who thinks that nothing will change. I do believe things will change, but it will take time.

You say that using hope as a compass was a decision made by your generation.

Where does your compass point today?

I had a lot of certainty up until the early 1990s. Because I belong to a generation that had a lot of certainty about the future, especially in Brazil, in Latin America. In the early 2000s, I lost that – which was okay, I think – but I am still energized and enthusiastic when I look forward. I want to look to the horizon and try to discern the outline of a utopia, no matter how fuzzy. We have to think critically about the present and understand that what we are living today is not 'natural' but rather the result of actions and contradictions by individuals throughout history. And, we must remember that patience is required, since we know that ideas bear fruit only over the long term, not within the timeframe for political action. ■

Works by artist duo
OSGEMEOS
appear in the publication



S&T POLICY

Annual balance

INDICATORS ▲

FAPESP continues its pace of investment according to the institution's 2016 report

Fabrcio Marques | PUBLISHED IN AUGUST 2017

In 2016, FAPESP invested a total of R\$1,137,355,628 in 24,685 research projects. This figure was slightly lower than investments in 2015, which totaled R\$1,188,693,702 for the 26,445 projects that were underway at that time. Despite the adverse situation resulting from decreased state tax revenue, which in turn is the product of the country's economic crisis, 10,480 new projects were contracted, an increase of 4% over 2015. Of these projects, 5,491 were scholarships in Brazil, 1,162 were scholarships

abroad, and 3,827 projects supported research. "The Foundation has been able to maintain its commitments and its rhythm of activity in research funding, despite the economic problems that Brazil faced in 2016," says FAPESP president and physicist José Goldemberg.

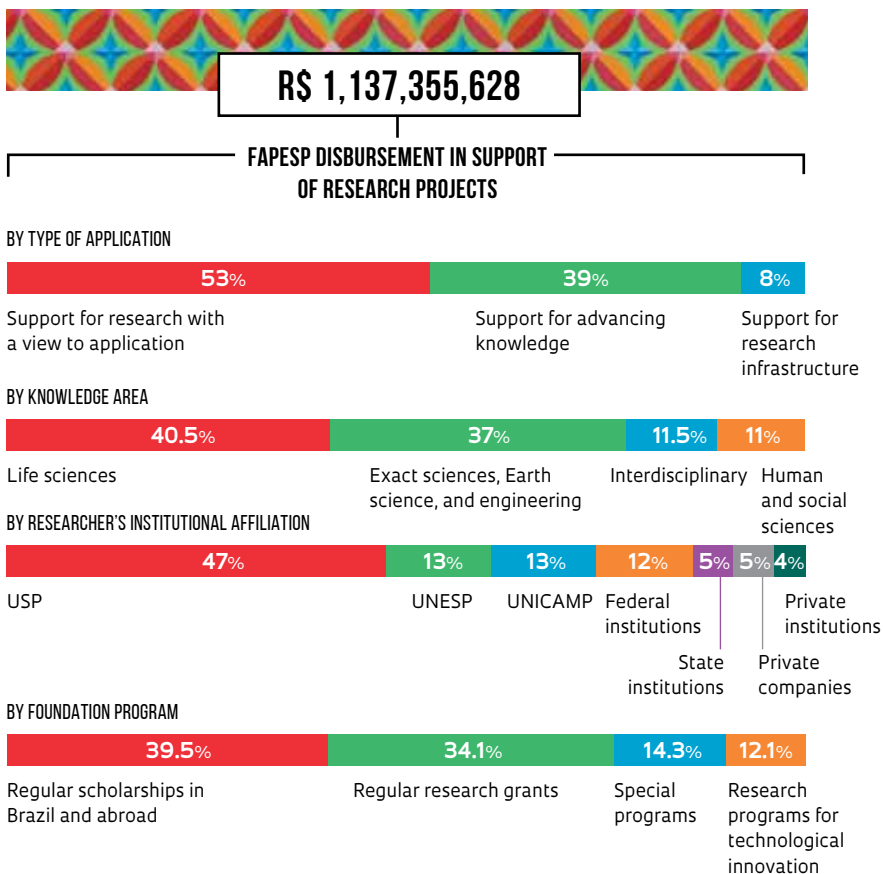
The Foundation's performance over the last year is presented in *Relatório de atividades 2016* (2016 Activity Report), which was released in August and is available at fapesp.br/publicacoes, where readers can also find yearly summaries

of FAPESP dating back to 1962, when the institution began operations. The cover of the 2016 report features works by the street artists Gustavo and Otavio Pandolfo, better known as OSGEMEOS, and some of these artworks also appear in this article.

The growth in cooperation with the business sector is one of the highlights of the report. The Innovative Research in Small Business program (PIPE) had its best year since it was created in 1997: 228 new proposals were contracted, nearly one per working day, and an investment of R\$55.5 million was made (see *Pesquisa FAPESP*, issue No. 257). In 2015, 159 projects were contracted, and the program's total disbursement was R\$29.9 million. PIPE was the first initiative by a Brazilian agency to provide grant resources for small and medium-sized companies to develop innovations in early stages. "It

How the resources were invested

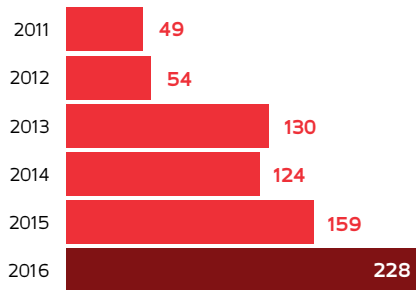
FAPESP disbursement in 2016 according to four classifications



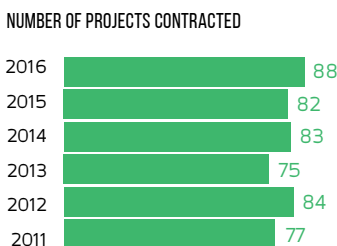
GROWTH IN PIPE
CHANGE IN NUMBER OF PROJECTS CONTRACTED IN THE INNOVATIVE RESEARCH IN SMALL BUSINESS PROGRAMS*

4 PROJECTS PER WEEK IN 2016

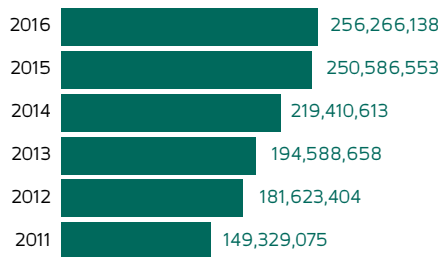
* Does not include scholarships



CHANGE IN THEMATIC PROJECTS



RESOURCES INVESTED IN PROJECTS AND RELATED RESEARCH GRANTS AND SCHOLARSHIPS (IN R\$)

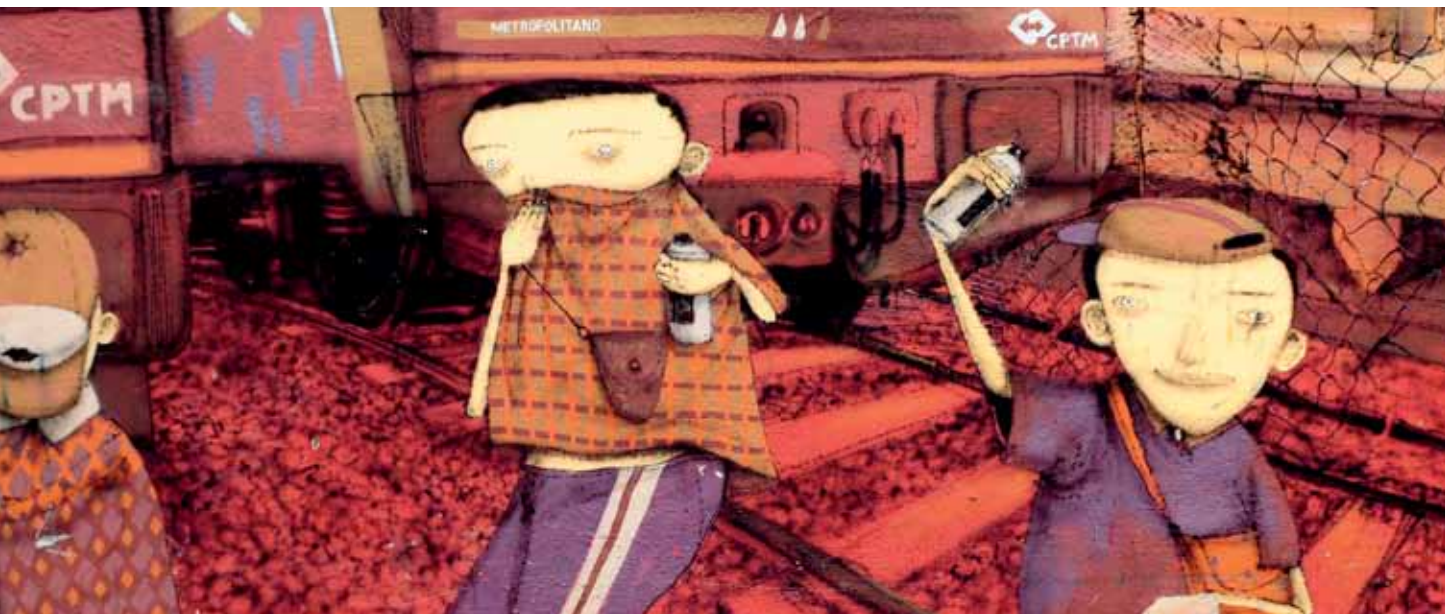


is a program that has made an enormous contribution to the scientific, technological, and economic development of the state of São Paulo, stimulating the creation of businesses that thrive and generate jobs and wealth,” says physicist Carlos Henrique de Brito Cruz, FAPESP’s scientific director.

The creation of engineering research centers in cooperation with companies was also driven in 2016 by the establishment of the Center for Applied Research in Human Well-Being and Behavior, a partnership between FAPESP, the Natura cosmetics company, the University of São Paulo (USP), the Federal University of São Paulo (UNIFESP), and Mackenzie University. The center, which is based at USP, is dedicated to multidisciplinary studies on human behavior and has received a joint investment of R\$40 million over 10 years. The idea is to bring together knowledge, methodologies, and technologies in areas such as experimental psychology and neuroscience, which create well-being indicators for the Brazilian population and help generate innovative products. Andrea Alvares, Natura’s vice president of marketing and innovation, stated that the model is at the forefront of open innovation. “The greater the diversity of the researchers involved, the richer the results will be,” she said at the event launching the center.

The partnership with Natura brings together four other centers established in previous years: two with the pharmaceutical company GSK, one with the carmaker Peugeot-Citroën, and another with the oil and gas company BG. In this model, each R\$1 invested by FAPESP will mobilize another R\$1 from the partner company and R\$2 from the university or research institute that houses the center. Together, these five centers will receive R\$259 million in investments.

Another highlight of the report was the growth in support for interdisciplinary research, a field which accounted for 11.5% of Foundation disbursement in 2016, behind life sciences (40.5%) and exact and Earth sciences and engineering (37%) but ahead of human and social sciences (11%). This performance surpasses that of 2015, when 10.4% of the Foundation’s funding went to interdisciplinary projects, and far exceeds that of 2006 (7.78%) or 2013 (3.08%).



Walls in São Paulo painted by the street artists

FAPESP has also maintained consistent investments in other inducement modalities that fund globally competitive research projects. The thematic projects, which involve bold goals that can justify funding up to five years and often bring together researchers from several institutions, received R\$256,266,138 in 2016, compared to R\$250,586,553 in 2015. These amounts include resources spent on the projects, as well as assistance and scholarships in the country and abroad that are tied to them. The number of projects contracted was the highest in the last six years, reaching 88, which is six more than in 2015 (see chart on page 17). There were 477 thematic projects underway in 2016. The Young Researchers in Emerging Centers program maintained a similar pace: it received R\$68.2 million in 2016, also including research grants and scholarships linked to 313 projects that are underway, compared to R\$67.3 million in 2015. Fifty-eight of these projects were contracted in the past year. The program finances the formation of centers led by young researchers with doctorates and high potential for up to four years, preferably at institutions that have not yet established traditions in the project area.

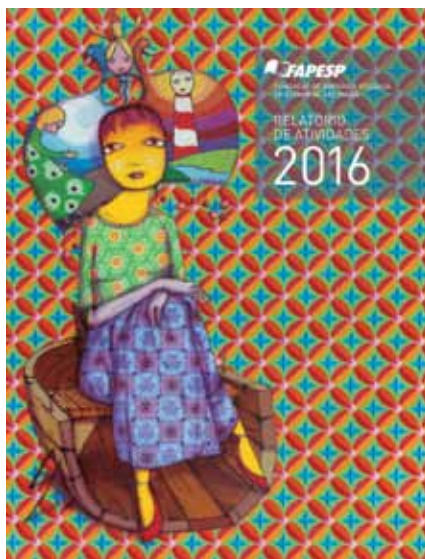
The 1989 state constitution provides FAPESP 1% of tax revenues from the state of São Paulo to invest in scientific and technological research. In 2016, the total amount forwarded from the state treasury totaled R\$1,057,714,553 and in nominal values exceeded the previous year's transfer by 1.2%. When the value

is corrected according to the Broad National Consumer Price Index (IPCA), there was a decrease of 5% compared to 2015. These funds from the treasury were responsible for 78.7% of the Foundation's revenue. The 2016 disbursement was supplemented with R\$215,154,402 which came from agreements and partnerships with other agencies, institutions, and companies, as well as R\$71,328,947 in revenue from the Foundation itself, which maintains profitable assets to complement the resources received from the treasury. In nominal terms, this revenue was 6% lower in 2016 than in 2015.

The reach of this investment can be seen from a number of different perspectives. One of these is the division of resources by FAPESP: 39.5% of disbursements went to scholarship grants in Brazil and abroad; 34.1% to regular research grants; 14.3% to special programs, such as those supporting young researchers and research in eScience; and 12.1% to technological innovation programs.

For the regular research grants, these resources were 9% lower than in 2015, and 3% fewer projects were contracted. This drop was more noticeable in indicators like participation in or organization of scientific meetings, while regular research grants (projects funded for up to two years) increased 17% and thematic projects grew by 9%.

Scholarship grant disbursements totaled R\$448.9 million, which was 6% less





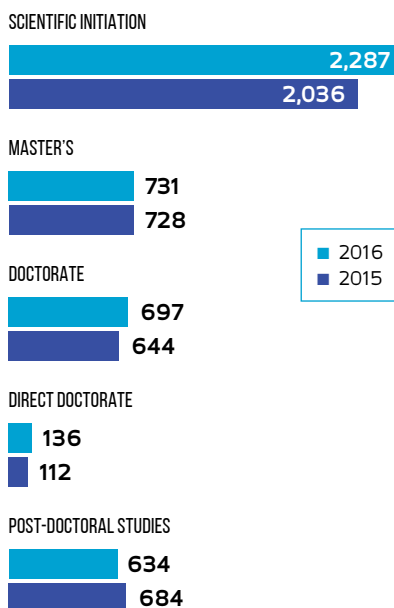
in nominal values than in 2015. Even so, there was a 4% increase in the number of new scholarship grants contracted, and current scholarship grants received an 11% adjustment. The main highlight for scholarship grants in Brazil was seen in scientific initiation: 2,287 scholarship grants were contracted, which is 12% more than the 2,036 grants in the previous year. The number of master's, doctorate, and direct doctorate grants grew 0.4%, 8%, and 21%, respectively. Post-doctorate study grants dropped from 684 scholarships in 2015 to 634 in 2016. Scholarships abroad fell 7%, with 1,162 in 2016 compared to 1,244 in 2015. This reduction was concentrated in foreign scholarship grants for internships lasting up to one year, depending on the modality. At the same time, foreign research grants rose from 254 in 2015 to 258 in 2016.

The number researchers abroad who obtained scholarships for post-doctoral studies in Brazil financed by FAPESP dropped from 123 in 2015 to 93 in 2016. However, the proportion of grants awarded to researchers from other countries remained stable, with 19% of all post-doctoral grants in Brazil, slightly below the level of 2015 (21%) but exceeding that of the five previous years, which ranged from 13% to 18%. The grant beneficiaries, who are generally foreign, worked in exact and Earth sciences (36%), engineering (26%), human sciences (26%), and applied social sciences (25%).

Another way to analyze the Foundation's investments distinguishes the re-

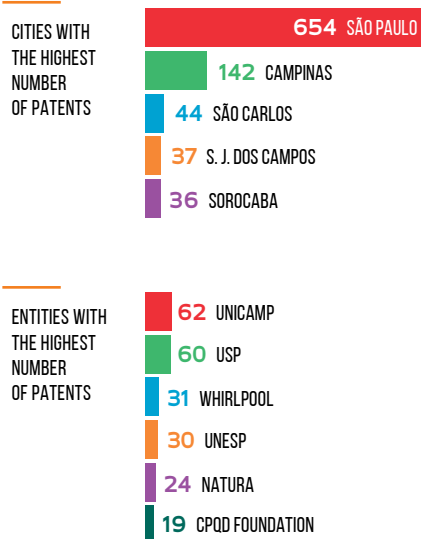
INVESTMENT IN SCHOLARSHIPS

SCHOLARSHIPS CONTRACTED IN BRAZIL BY FAPESP



NUMBERS FOR INNOVATION IN 2016

1,599
INVENTION PATENTS
 WERE FILED WITH INPI BY
 RESIDENTS OF SÃO PAULO STATE
 (31% OF THE TOTAL)



search support objectives. Using this criterion, we see that 53% of the funds were directed toward applied studies. This item includes research grants and scholarships in areas such as agronomy and veterinary medicine, engineering, and health, which almost always result in applications. This is in addition to programs that stimulate innovation in universities and companies and some special Foundation programs. Another 39% of funds were invested in supporting the advancement of knowledge through programs that comprise human resources and stimulate academic research, including grants and scholarships. Finally, 8% of funds supported research infrastructure, enabling the recovery, modernization, and purchase of equipment for laboratories, expansion of library collections in teaching and research institutions, and ensuring high-speed Internet access for researchers.

Investments in the Multi-User Equipment program (EMU) for the purchase of high-value equipment that can be made available to a large number of researchers totaled R\$37.5 million in 2016, including 134 projects that were linked to regular research grants, thematic projects, and the Young Researchers program. This amount also includes four specific EMU projects, which cost R\$1.3 million.

Throughout 2016, there were cooperation agreements between FAPESP and 94 organizations; 28 of them were signed that year. Of all the development agencies and academic institutions with which new agreements were signed, only one was Brazilian: the National Institute for Space Research (INPE). The other 24 agreements were signed with foreign institutions, including 7 in the United States; 3 each in the United Kingdom and Australia; 2 each in Canada, France, and China; and 1 each in the Netherlands, Italy, Norway, Chile, and with a multinational agency. Among these organizations, three were companies: Statoil (Norway), Koppert (the Netherlands) and IBM (the United States). In 2016, two scientific symposia were held in the FAPESP Week series, which seeks to stimulate scientific collaborations between researchers from São Paulo and other countries; one of these was held in March in the United States, and another in November in Uruguay. ■

Reasons to award incentives

The IMF and the OECD suggest that governments provide tax incentives to encourage companies to conduct more research

Bruno de Pierro

PUBLISHED IN JUNE 2017

Granting tax incentives in the form of tax reductions to companies that invest in research and development (R&D) has become more widespread in the last decade. For example, in France and Japan, this type of support represents more than 70% of the set of tools used by governments to finance promotion of innovation in the private sector. In the early 2000s, that proportion was 20% according to data from the Organization for Economic Co-operation and Development (OECD), whose members include some of the world's most industrialized countries. Publicized in countries like Brazil and South Africa, the model recently became the subject of studies by the OECD and the International Monetary Fund (IMF). Although often viewed as more orthodox, both organizations recognized the role of the State in funding research at universities and in

companies. "To a large extent, future economic growth is expected to be the result of productivity improvement. That puts discussion about government innovation support policies at the center of the political debate," economist Ruud de Mooij, division chief of the IMF's Tax Policy Division, told *Pesquisa FAPESP*. In March, he published an article in the magazine *Finance & Development* in which he discusses the impact and effectiveness of tax policies and makes recommendations to officials and decision-makers based on the Fiscal Monitor report released by the IMF in 2016.

Mooij emphasizes that many companies spend little on R&D because they know the investments made will benefit other firms as well as their own. "Creation of knowledge overflows and benefits other firms in addition to the one responsible for the investment," he observes.





The IMF suggests that incentives be directed towards technology-based startup companies. This is unlike what happens in many countries, where advantages are given to well-established small businesses. “The idea is that a lower tax rate would encourage innovation activities in those small companies, but that does not always happen in practice,” the economist observes. “A small company may not consider it very attractive to become a big one when it realizes that it might lose the tax incentives by doing so.” According to Mooij, there are surveys showing that many small companies stop growing once they reach the highest level of income that allows them to retain tax incentives. This situation occurs less frequently in the case of startups. Mooij argues that by concentrating assistance on nascent companies, it is easier to ensure that the tax incentives are temporary. Countries like Chile and France, he says, have adopted tax policies in line with that way of thinking.

In the report *Fiscal incentives for R&D in a diverse world* (published in 2016), the OECD also confirms the necessity of offering tax incentives to startups that need capital in order to invest in new technologies. The organization warns, however, that tax incentives should be understood as part of an arsenal of options for fostering R&D in the private sector and that it is up to the decision

makers to evaluate the solution in terms of suitability to local realities. For example, in the United States, a great deal of support to companies comes in the form of government procurement. In Europe, tax incentives are used more widely—even in Germany, although to a lesser extent.



Brazilian industrial policy established incentives for automobile production

Another recommendation by the IMF is that emerging economies stop offering tax benefits to multinationals in order to encourage them to establish operations in their countries. Instead, it suggests that governments invest in education, infrastructure, and research institutions to enhance their ability to absorb new knowledge and encourage the transfer of technologies developed by the more advanced economies. According to the Fund's report, many countries are sacrificing their tax base by awarding incentives to attract foreign capital. "In fact, tax incentives have relatively little effect on the choice of a site in which to invest," comments Rafael Cagnin, an economist from the Industrial Development Study Institute (IEDI). He points out that the size of a country's market, the degree of its integration in the international economy and the quality of its infrastructure and business environment have more influence on investment decisions than potential tax benefits. The IMF's Mooij mentions the example of China, which began eliminating various tax incentives for foreign investment in 2008 while still continuing to attract funds. "For tax purposes, China gives equal treatment to domestic and foreign companies that establish there, without discrimination," Mooij says.

TAX INCENTIVE ACT (*LEI DO BEM*)

In Brazil, tax incentives for R&D and technological innovation are called for in instruments like the 2005 *Lei do Bem*, the revision of which is being discussed in the National Congress. "One of the problems with that law is that it has not been

able to promote incentives for small companies, favoring instead the more established firms," says attorney Aristóteles Moreira Filho, a researcher at the Center for the Study of Society and Technology of the University of São Paulo (Poli-USP). The justification, according to Moreira, is that the law permits an additional deduction from 60% to 100% of R&D expenditures, but only for companies that calculate income tax on their actual profit. "Small companies and new technology-based companies end up disadvantaged by that logic either because they have not opted for taxation on actual profit or because they lack a portfolio of products and services, so it takes a long time to turn their innovative ideas into profit." Another problem is that the incentives granted by the *Lei do Bem* can be suspended if a company experiences financial problems. "Even if a company continues its R&D activities in a year when it records a loss, the tax deduction will be suspended," explains Luiz Eugênio Mello, vice president of the Brazilian Association for Research and Development of Innovative Companies (ANPEI).

To Mello, who is also executive manager of Innovation and Technology at the Vale company, the law needs to create conditions to benefit small and new companies but must also emphasize that tax incentives are also important to big companies. "Vale's annual investment in research is on the order of hundreds of millions of *reais*. Tax incentives allow us a return of about R\$15 million. To a company that has many shareholders and is trying to increase its stock price, that's a significant sum."

The 2014 Innovation Research Survey (PINTEC) published in December 2016 by the Brazilian Institute of Geography and Statistics (IBGE) shows that the tax incentives available in the law were used by only 3.5% of innovative companies.

PATENTS

In recent years, the so-called *patent box* regimes have gained popularity in Europe. Under those systems, taxes are waived on the profit generated from patented products. In the opinion of the IMF, that model has not been successful in encouraging innovation at companies. “Many R&D projects do not result in patents or lead to profitable innovations,” Mooij observes. “Fiscal support is more efficient when it directly reduces the cost of research.” To Aristóteles Moreira Filho, patent box regimes are controversial since they affect the last step in the process of innovation. “Since the incentive applies to the profit obtained from a patent, we are beginning to see, in countries that grant such benefits, cases of

Rafael Cagnin from IEDI believes that tax incentives tied to the income earned from the sale of finished products may not be very effective. “The process of innovation entails unanticipated mistakes or changes. It is better to give tax incentives at the beginning of the process because, even if the achievement of an end product is uncertain, the stages in that research enable a company to take advantage of lessons learned,” says Cagnin. “In that regard, tax incentives are a fundamental piece of industrial policy. It’s the public sector participating in the sharing of the risks that innovation involves when private returns on investment are neither easily calculated or certain.”

Moreira argues that tax incentives grants should be directed to different industrial sectors indiscriminately in order to not become unfair. In his opinion, granting sectoral incentives is not the most efficient method, and it also tends to be antidemocratic. “Let’s stop taking from one pocket in order to overstuff the other one. Sectors with greater political clout have more power to wield influence

in dealings with the government and so are able to impose their agendas in an unequal manner in relation to sectors that are less influential but that also need incentives in order to grow,” he suggests.

Brazilian industrial policy established in-

According to the IMF, tax incentives to attract multinationals sacrifice emerging countries and bring little benefit

centives to boost domestic production of automobiles, computers and related equipment, semiconductors, and other products. In that case, the strategy currently adopted is still to grant exemptions from or suspensions of taxes that would otherwise be assessed on the end product. That policy is not extended to imported competing products (*see Pesquisa FAPESP Issue No. 251*). Early in 2017, programs such as Inovar Auto and the Informatics Law were deemed illegal by the World Trade Organization (WTO), having been challenged by both the European Union and Japan. “Unfortunately, the attitude toward incentives in Brazilian tax policy is ‘all or nothing’,” observes economist José Roberto Rodrigues Afonso, a professor at the Getúlio Vargas Foundation and a World Bank consultant. He says that during the previous Brazilian administration, exemptions were awarded indiscriminately without taking technical evaluations into consideration. “Under the current administration, we find just the opposite: any incentive has come to be seen as a capital sin,” says Afonso. “Brazil stands outside the international debate and seems unable to find a political equilibrium and the technical competence to support its fiscal policy,” he adds. ■

companies—especially multinational groups—that did not invest directly in R&D but simply incorporated their intellectual property assets in holding companies that have no substantial economic activity. They may even acquire patents from third parties to gain access to tax incentives without promoting any additional volume of investment in innovation,” Moreira says. In 2015, the OECD began to require its member countries to apply the patent box regime only to patents that were developed by the company awarded the incentive. One suggested change in the *Lei do Bem* is the elimination of the concession of increasing incentives to someone who files for a patent; this is aligned with the idea that an incentive can be given even if there is no patent. Another demand being evaluated is to allow the incentive to include R&D that is contracted out to small companies and startups. The purpose is precisely to strengthen emerging companies as well as reinforce corporate venture strategies, which consist of setting up business units devoted to innovation within big companies. Many startups acquired by well-established companies have been converted into such innovation units.

centives to boost domestic production of automobiles, computers and related equipment, semiconductors, and other products. In that case, the strategy currently adopted is still to grant exemptions from or suspensions of taxes that would otherwise be assessed on the end product. That policy is not extended to imported competing products (*see Pesquisa FAPESP Issue No. 251*). Early in 2017, programs such as Inovar Auto and the Informatics Law were deemed illegal by the World Trade Organization (WTO), having been challenged by both the European Union and Japan. “Unfortunately, the attitude toward incentives in Brazilian tax policy is ‘all or nothing’,” observes economist José Roberto Rodrigues Afonso, a professor at the Getúlio Vargas Foundation and a World Bank consultant. He says that during the previous Brazilian administration, exemptions were awarded indiscriminately without taking technical evaluations into consideration. “Under the current administration, we find just the opposite: any incentive has come to be seen as a capital sin,” says Afonso. “Brazil stands outside the international debate and seems unable to find a political equilibrium and the technical competence to support its fiscal policy,” he adds. ■

Sleeping Beauties

To study the scientific process and perfect evaluation systems, researchers analyze innovative papers whose value was recognized only belatedly

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Researchers who follow the progress of scientific production in their fields know that good papers do not always have an instant impact. It is not unusual for innovative ideas to languish for some time before their importance is recognized. Winners of the Nobel Prize frequently receive the award for contributions made many years – and sometimes decades – earlier, just as applications based on well-known concepts may gain significance unexpectedly. Experts in scientometrics, the branch of science that studies the quantitative aspects of the production of knowledge, have coined the term “sleeping beauties” to describe articles that arouse interest years or even decades after they were first published. They have begun to study these articles as expressions of a delayed recognition of scientific production.

One famous—and extreme—case was that of American virologist Francis Peyton Rous, who in 1911 published an article demonstrating that some types

of skin cancer observed in birds were caused by an RNA virus, one of the retroviruses. The importance of Rous’s work did not become apparent until 1951, after a leukemia virus had been isolated. That accomplishment marked the beginning of the association between cancer and infections caused by viruses. In 1966, Rous was awarded the Nobel Prize in Medicine. Similar occurrences have been analyzed in studies that attempt to understand the nature of sleeping beauties and identify the factors that help awaken them.

Physicist Anthony Van Raan, a researcher at Leiden University in the Netherlands, says that one must keep in mind that sleeping beauties with the potential to bring about paradigm shifts are fairly rare, which makes identifying them a complicated task. “The great majority of articles that pass unnoticed will remain so forever, simply because they are not interesting,” says Raan, who was the first to coin the term “sleeping beauties” to refer to papers that took time to

be recognized and make an impact. Van Raan’s most recent works are intended to identify the “princes” responsible for breaking the spell and sparking an interest in long-dormant articles.

In an article published in February 2017 in the journal *Scientometrics*, Raan showed that in the field of physics, 16% of the sleeping beauties indexed in the Web of Science were awakened when they were mentioned in patents. He also observed that the average time lag between the publication year of a sleeping beauty and its first citation in a patent appeared to decrease in the early 1990s. “That would mean that sleeping beauties having technological importance, perhaps potential inventions, are being discovered increasingly earlier,” Raan suggests. He says it is common for good articles that present concepts or technologies that are ahead of their time to go unnoticed. In 1958, for example, an article was published that described an efficient way to obtain graphite oxide on a large scale. Citations of the study



did not begin until 2007, when it was discovered that graphite oxide could be useful in obtaining graphene on an industrial scale. Graphene is an extremely hard and malleable material described as a carbon sheet with thickness at the atomic level and possessing electrical, mechanical and optical properties.

Physicist Ado Jório de Vasconcelos, a professor at the Federal University of Minas Gerais (UFMG), published a paper in 2002 in which he described the application of a technique known as Raman spectroscopy in the identification of the properties of carbon nanotubes, considered to be good conductors of heat. “The article did not begin to be cited actively until 2010, when the scientific community began to attach importance to the study of the Kohn anomaly, a characteristic of the vibration in atomic nuclei that are coupled with electrons. That phenomenon was known to appear in metallic materials. My work had already shown that it was also a characteristic of nanotubes,” says Jório, who in 2016

was included on the list of the “3,000 most influential scientists in the world,” published by Thomson Reuters.

EVALUATION

Studies about the delayed recognition of papers also seek to perfect the evaluation systems employed in science, many of which are based on indicators that appear to favor papers whose impact is felt soon after publication. A paper published in April 2017 in the journal *Nature* suggests that scientific articles that made transformative contributions, even if they did not strictly fit the definition of sleeping beauties, usually took more time to produce repercussions than did articles that took incremental steps forward. Jian Wang, a researcher at The Catholic University of Leuven (KU Leuven) in Belgium and one of the authors of the study, told *Pesquisa FAPESP*, “We observed that truly innovative research studies did not receive citations until after a long period starting seven years after publication.” The survey concluded that bibliometric in-

Latent knowledge

Examples of scientific articles that were not recognized until long after publication

FORECASTING SYSTEMS

Mathematician Charles Sanders Peirce published an article in *Science* in 1884 about ways to measure the success of weather forecasts. Since the 2000s, his work has been cited in studies on meteorology, medicine, and economics



EINSTEIN PARADOX

In 1935, Albert Einstein published a paper with two other physicists suggesting that the current theory of quantum mechanics was incomplete. The article “woke up” in the 1990s and now receives approximately 100 citations a year



GRAPHENE

A 1958 article by William Hummers and Richard Offeman described a method for obtaining graphite oxide. In the 2000s, the paper began to be cited in studies about the production of graphene, a very tough material



SOLAR CELLS

An article signed by William Shockley and Hans-Joachim Queisser in 1961 discussed the limit on the conversion of solar energy into electricity. In the 2000s, when progress had been made in research on solar cells, the paper gained significance. Now, it has 4,000 citations



THE IMPACT FACTOR

U.S. chemist Eugene Garfield proposed the concept of the impact factor in 1955 and based it on the number of citations received by articles. During the 2000s, the idea was cited frequently in studies on scientometrics

dicators that employ a citation period of only three years are clearly inefficient for evaluating research whose results need time in order to be understood.

Wang and his team examined the citations of more than 660,000 articles published in 2001 in all the fields of knowledge indexed in the Web of Science database. They found that 89% of manuscripts featured only a low degree of innovation. In order to determine which articles would be considered innovative, they selected papers that presented unusual bibliographic references, combining authors and fields of knowledge differently than had been the pattern in each field. “One way to verify whether an article contains new ideas and concepts is to look at its ability to combine different bibliographic references in an unprecedented fashion. That characteristic may point to those papers in which the researcher took more risks,” Wang explains.

It was found that during the first three years after publication, the likelihood that a very innovative article would be found among the 1% most frequently cited papers was lower than the probability ascribed to the other papers. According to the survey, papers that received many citations soon after publication and during the first three years tended to become obsolete. “But those that were considered disruptive, that introduced a high degree of novelty, accounted for 60% of the most-cited articles 15 years after publication,” Wang explains. He concludes that although funding agencies highlight the importance of investing in research of a transformative nature, their evaluation systems end up favoring incremental studies because they use the more popular indicators of impact. “Funding agencies’ and reviewers’ widespread use of parameters such as number of citations may discourage research efforts that have a potential for overturning paradigms,” Wang suggests.

As examples of agencies that make some use of bibliometric indicators in their evaluation procedures, the survey mentions the European Research Council (ERC), the National Natural Science Foundation of China (NSFC), the U.S. National Science Foundation (NSF), and the Brazilian Federal Agency for the Support and Evaluation of Graduate Education (Capes), which established the QUALIS system for classifying Brazilian

The scientific community is often shocked by ideas outside the mainstream, says Paulo Artaxo



scientific journals. Rita Barradas Barata, director of evaluation at Capes, explains that in order to supervise the approximately 4,200 graduate study programs in Brazil, the institution monitors scientific production by faculty and students. “Since it is impossible to measure the quality of each of the more than 800,000 articles produced by those programs, we designed a classification of the vehicles in which the works are published,” she reports. To that end, consideration is given to various indicator disciplines such as the Journal Impact Factor (JIF), identified in Wang’s study as one of the tools that disadvantages articles that take a long time to be recognized.

Barata acknowledges that institutions have become accustomed to concentrating their attention on articles that are cited many times within a short interval. “There is a tendency to train the eye toward the ones that bibliometric indicators say are good at the time.” One idea being discussed, according to Barata, is that research agencies and institutions could adopt the practice of “prospecting” to unearth topics whose potential impact may be underestimated. In Wang’s opinion, agencies do not need to look for ways to favor researchers who

are not often cited. “It’s enough to judge each proposal on its own merits, which is hard to do. Peer evaluation systems are a good counterpoint to the excessive use of metrics,” he says.

IMPACT FACTOR

In a study published in 2015 in the journal *PNAS*, researchers from Indiana University in the United States analyzed 22 million papers published over a period of 100 years that were indexed in the archives of the American Physical Society and the Web of Science. They found that the bulk of the articles that remained dormant for long periods of time but then became celebrated in their respective fields dealt with chemistry, physics, and statistics. The study by Indiana researchers calls attention to the fact that the very concept of an “impact factor” remained hidden for years in an article published in 1955 by Eugene Garfield. In that article, Garfield, who died in February 2017, presents ideas and concepts that would later be used to consolidate the Web of Science database maintained by Thomson Reuters. “The paper had been dormant for almost 50 years until it became popular in the early 2000s and was cited in works on bibliometrics,

some of them by Garfield himself,” the study reports.

Van Raan explains that although they are concentrated more in the exact sciences, sleeping beauties can be found in practically all areas of knowledge. “I am beginning to investigate medical fields as well as the social sciences and hope to discover some interesting things,” says Raan, who is counting on the development of software that would be able to identify the sleeping beauties of science.

Paulo Artaxo, a professor at the Physics Institute of the University of São Paulo (USP), sees it as natural that good articles do not receive proper recognition at first glance. “Research projects involving ideas well outside the mainstream take time to be digested by the scientific community, which often tends to be shocked by new ideas and may even exhibit some prejudice,” he explains. He says that studies that try to analyze sleeping beauties may play an important role. “They may provide us with paths to an understanding of why big ideas go unnoticed. This is an opportunity for us to alert publishers to come up with strategies to make articles more visible and readable, because today there is an excessive degree of specialization in these research papers, which makes them hard to understand even for someone who is versed in that same field of research,” Artaxo observes. However, Ado Jório argues that it is up to the authors of the research papers to make an effort to publicize them, especially when they know they are proposing something that conflicts with the prevailing paradigm. “It’s not enough to publish an article and pray that it is read, understood and cited.” He recommends that researchers attend conferences, lectures and debates and continually look for occasions to talk about their research with people who may be interested in it. ■ Bruno de Pierro

REVERSING WASTING SYNDROME

Physical exercise can halt cachexia,
the inflammation that induces
unwanted weight loss and worsens
cancer and other diseases

Carlos Fioravanti

PUBLISHED IN AUGUST 2017

*Trois hommes qui
marchent*, Alberto
Giacometti, bronze with
brown patina, 1948

Five years ago, surgeon Paulo Alcântara was intrigued to see that two patients of the same age and with the same type of advanced bowel cancer who had been treated during the same week at the University Hospital of the University of São Paulo (HU-USP) responded differently to the same treatment. One patient was obese, while the other was very thin. The thin patient's lack of body mass was a manifestation of cachexia, a syndrome characterized by continuous loss of muscle mass and appetite that can accompany (and worsen) not only cancer but also AIDS, heart failure, and chronic obstructive pulmonary disease (COPD). Seen in 40% of people with cancer and 80% of patients hospitalized with malignant tumors, cachexia makes treatment difficult and is associated with 20% of deaths caused by this disease. The thin patient died a year and a half after treatment as a result of cancer and cachexia, while the other patient lived for another four years.

Intrigued by this situation, Alcântara sought the help of biologist Marília Seelander, who has been studying physical exercise, inflammation, and cancer at the USP Institute of Biomedical Sciences (ICB-USP) for 25 years (*see Pesquisa FAPESP, issue No. 89*). Based on the results of experiments in animal models, the two researchers planned a study to evaluate the possible effects of physical activity on people with cancer and cachexia.

Preliminary results from the tests performed within the University Hospital indicate that a physical exercise regimen—in this case, walking or running on a treadmill for one hour a day for six weeks—can reduce the inflammatory processes that result in weight loss in cases of cachexia. Participants with cancer and cachexia who exercised recovered muscle mass and appetite and exhibited better postoperative



recovery than those without cachexia. There was also a change in the patients' cytokine profiles. Cytokines are proteins that activate defense cells. In these patients, the levels of proinflammatory cytokines, which cause and worsen cachexia, were found to have fallen, while anti-inflammatory cytokine levels rose.

Thus far, 332 patients with cancer of the stomach, pancreas, or intestine—some of whom experienced cachexia—have participated in the study; 272 were placed in the sedentary group, and 50 underwent physical training. “The blockage of cachexia could allow for a more intensive treatment, improve quality of life, and increase patient survival,” says Alcântara. “However, we have to reach 100 cases in each group of patients—with and without cancer and with and without cachexia—to produce statistically significant results.” The ongoing studies, proposed in a 2015 article in the journal *Current Opinion in Supportive and Palliative Care*, integrate teams from USP, the São Paulo State Cancer Institute (ICESP), Santa Casa Hospital of São Paulo, and Santa Marcelina Hospital.

Scientific research has yet to be completed on the effect of physical exercise on people with cancer and cachexia, but the effect of physical exercise have been observed in COPD patients. A group of researchers from Germany and the Netherlands found that four months of intense exercise contributed to improved health and muscle strength in people with COPD and cachexia relative to patients who received nutritional supplements and to controls. The study included 81 patients and was published in June of this year in the *Journal of Cachexia, Sarcopenia and Muscle*.

“The metabolic changes characteristic of cachexia weaken the body, favor tumor growth, and make treatment difficult,” Alcântara explains. On June 13, he attended a meeting at ICB-USP, where researchers from Seelander's team presented the results of blood and tissue analyses performed on subjects from the University Hospital. Individuals with cachexia exhibited a reduction in protein metabolism and in the levels of two

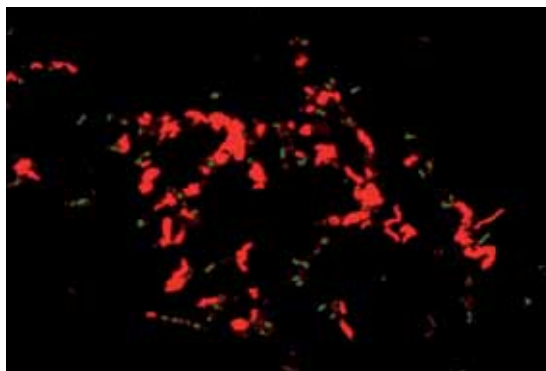
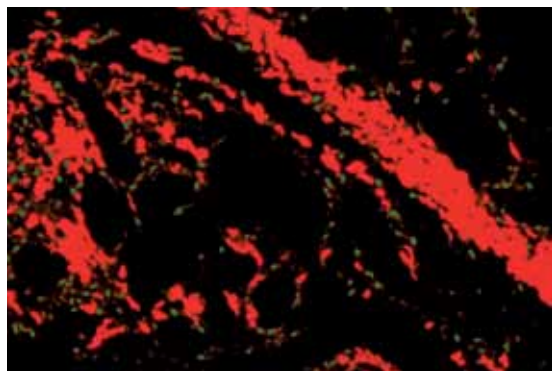


USP's University Hospital exercise room was used to help patients regain weight

Physical exercise has been found to limit cachexia-related inflammation in people with chronic lung disease

hormones: leptin, which regulates appetite, and insulin, which aids in glucose uptake by cells. The functioning of the hypothalamus, a region of the central nervous system that controls hunger, was also affected. Bacterial communities in the gut, which may cause or aggravate inflammatory processes, were found to have changed, and the muscles, including those of the heart, were found to have weakened. “The imbalance caused by cachexia is so intense that people continue to lose weight, even when they receive nutritional supplementation, because the cells can no longer absorb the nutrients,” says Seelander.

Cachexia was first recorded by the Greek physician and philosopher Hippocrates (460–370 BC)



Collagen protein production (*in red*) intensifies in people with cancer and cachexia; it results in the formation of fibers that impair the function of fat cells (*left*). Patients with cancer and without cachexia have less collagen (*right*)

WASTING SYNDROME

Cachexia develops as a result of inflammation that spreads throughout the body

SOURCE

In response to a tumor, defense cells produce inflammatory proteins, such as interleukin-6 (IL-6), which enter the bloodstream

INITIAL RESPONSES

Subcutaneous adipose tissue accumulates IL-6 and defense cells, which cause local inflammation

Fat cells release fatty acids, which spread the inflammatory reaction to other tissues and organs

CONSEQUENCES

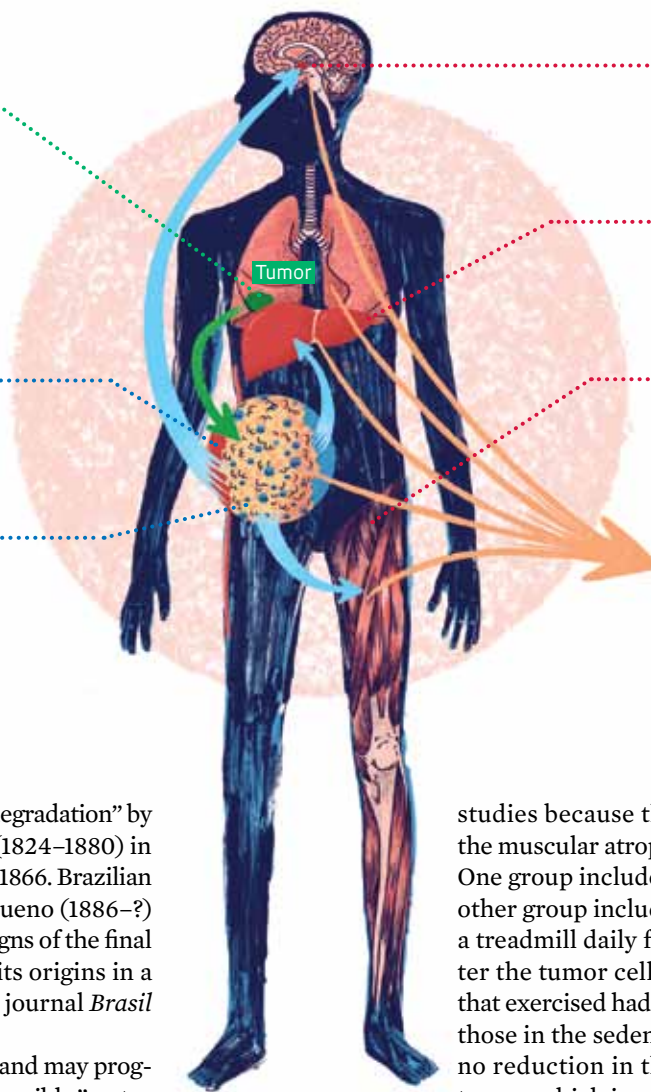
The hypothalamus reduces the production of hormones that activate appetite

The liver increases the production of proteins that intensify inflammation

Muscle tissue begins to atrophy

RESULTS

The body's physiological imbalance intensifies and becomes irreversible



SOURCE USP AND UMC

and was described as a “profound degradation” by the French physician Paul Broca (1824–1880) in his treatise on tumors published in 1866. Brazilian physician Alfredo Leal Pimenta Bueno (1886–?) presented cachexia as one of the signs of the final stage of cancer, and he analyzed its origins in a series of articles published in the journal *Brasil Médico* from 1926 to 1928.

“Cachexia favors tumor growth and may progress to the point of becoming irreversible,” notes oncologist Gilberto de Castro Jr. of ICESP. Treating the tumor does not always cure cachexia. “Physical exercise is somehow able to block it and serve as supportive therapy,” he says. “We still have to determine the most adequate intensity, frequency, and duration of exercise, but we need to get cancer patients to move more.” Several studies have already indicated the benefits of physical exercise in the fight against cancer (see sidebar on page 32).

IN THE LABORATORY

“Physical exercise minimizes cachexia,” agrees physical education professor Patrícia Chakur Brum, whose conclusion is based on her experiments with animal models at the School of Physical Education and Sports at USP. She and her team used two groups of mice with Walker 256 tumors; these tumors are used in experimental

studies because they grow rapidly and induce the muscular atrophy characteristic of cachexia. One group included sedentary animals, and the other group included animals that exercised on a treadmill daily for 15 days starting the day after the tumor cells were injected. The animals that exercised had 31% higher survival rates than those in the sedentary group, though there was no reduction in the rate of progression of the tumor, which is an aggressive type.

Brum’s findings suggest that aerobic exercise can improve the functioning of muscle cells in animals with Walker 256 tumors. “Physical exercise may not directly affect the tumor, but it does render the muscles more functional,” she says. Her group has also found that previous physical activity may delay the onset of skin and breast tumors in mice. In Seelander’s laboratory at ICB-USP, the results were more dramatic: in the animals that exercised on a treadmill or swam as part of a longer exercise program, the size of the Walker 256 tumor decreased by 50%.

Though the loss of muscle is the most visible manifestation of cachexia, it is not the cause; it is one of the consequences of the process in which the body consumes itself. “We still do not know how or when cachexia begins,” acknowledges physical education expert Miguel Luiz Batista Júnior, a professor at the University of Mogi das

WORKING OUT: PART OF PREVENTION

Physical exercise helps prevent cancer, aids in recovery after surgery, and reduces the side effects of medications, the recurrence of tumors, and mortality rates, according to studies performed in the United States. In a June 2016 article in *JAMA: The Journal of the American Medical Association*, Steven Moore and his epidemiology team at the National Cancer Institute in the United States presented a meta-analysis of 12 studies from the United States and Europe that considered the effects of physical activity on 26 types of cancers in 1.4 million people over the course of 11 years. Researchers associated moderate or intense physical activity (such as walking) during leisure time with a lower risk of 13 types of cancer, as well as with a 42% drop in esophageal tumors and a 10% decrease in breast tumors, even among obese people and smokers.

If doctors and people with cancer were to adopt physical exercise as part of treatment, they would be following the same pattern witnessed years ago in the treatment of heart disease, according to Carlos Eduardo Negrão, a professor at the School of Physical Education and Sports of the University of São Paulo School of Medicine and director of the Cardiovascular Rehabilitation and Exercise Physiology Center of the Heart Institute (InCor), also



Aerobic exercises, such as running and cycling, are recommended to help prevent cancer and to reduce the unwanted effects of medications

within the University of São Paulo (USP). “Until the 1970s, people with heart failure were advised not to exercise; later, it became a more common recommendation, and it is now an important part of treatment,” he explains (see *Pesquisa FAPESP*, issue No. 238). “In the case of cancer treatment, we’re most likely going to go down a similar path.”

Two recent studies by his group at InCor published in 2014 and 2016 in *The American Journal of Physiology – Heart and Circulatory Physiology* showed that physical exercise in people with heart problems can deactivate protein degradation processes in muscle cells, stimulate the production of anti-inflammatory cytokines, and improve the flow of calcium. These phenomena are essential for proper muscle functioning, especially in the case of the heart, the functioning of which may be hindered by anti-tumor drugs or cachexia. In an article published in May in *Oncology Reports*, researchers in France argue that “physical exercise appears as an interesting non-pharmaceutical way to counteract cancer cachexia-induced-heart failure.” They found that aerobic training has anti-inflammatory effects and prevents heart muscle atrophy.



Low levels of albumin and high levels of C-reactive protein could indicate the onset of cachexia

Cruzes (UMC). The onset of the syndrome is likely inflammation triggered by an intense production of both proinflammatory cytokines and interleukin-6 (IL-6), a process that occurs as a result of the actions of defense cells against tumors. “The level of IL-6 circulating in the bloodstream increases two- to threefold in people with cancer, and levels are five to six times higher [than normal] in patients with cachexia,” says Batista, who has studied the mechanisms of cachexia since 2008 as part of a collaboration between USP and the University of Boston in the United States (see the infographic on page 31).

OTHER STRATEGIES

Based on tissue samples from cancer patients, the teams from UMC and USP concluded that subcutaneous white adipose tissue atrophies and becomes fibrous as a consequence of the accumulation of defense cells and the formation of an external mesh of collagen proteins on adipocytes, as detailed in a 2016 article in the *Journal of Cachexia, Sarcopenia and Muscle*. “As a result, adipose tissue loses its ability to store energy for the body,” says Batista.

In his laboratory, Batista tested pioglitazone, a medication that has been used to treat diabetes, to see whether it could slow or stop the progression of cachexia. The drug hindered muscle mass reduction and increased survival of Walker 256 tumor-bearing rats by 27% relative to the controls. Published in *PLOS One* in 2015, the study argues that pioglitazone could be effective in both the early and late stages of cachexia by reducing insulin resistance and facilitating glucose uptake by cells, though it may cause damage to the heart. Current clinical trials in the

United States are also assessing the possible uses of metformin, another antidiabetic drug, as well as other medications, such as ghrelin and anamorelin.

At the Institute of Biology of the University of Campinas (IB-UNICAMP), biologist Maria Cristina Marcondes found that leucine, an amino acid with anti-inflammatory properties, prevents muscle degradation in Walker 256 tumor-bearing rats. “The tumor continues to grow, but animals regain at least 25% of muscle mass,” she explains. Her group is also looking for molecular markers that can be used to detect the onset of this syndrome. This information is useful for medical teams who treat people with cancer and cachexia and would like to make a diagnosis and act as soon as possible to avoid weight loss and physiological imbalance.

Seelander notes that because the measurement of IL-6 and other inflammatory cytokines is expensive, an alternative would be to examine both C-reactive protein (CRP) levels in the liver and hemoglobin and albumin levels in the blood. According to Seelander, high CRP levels or albumin and hemoglobin levels well below normal could indicate the onset of cachexia before loss of muscle mass occurs. In addition, clear spots seen on the muscles in CT scans could indicate the infiltration of fat or adipose tissue cells, signaling the onset of an inflammatory process that can lead to muscle loss.

As the research evolves, these proposals are likely to help stop a problem that is typically not detected until the loss of muscle mass is already evident. In the coming years, cachexia treatment may combine several strategies, such as the use of dietary supplements, physical exercise, and new drugs, in an attempt to prevent the physiological imbalances that contribute to the progression of cancer and other diseases. Meanwhile, Paulo Alcântara is still driven by the unanswered question that has guided his research for the last five years. Thus far, there are only guesses as to why some people experience cachexia and others do not, even when they are the same age and in the same stage of cancer. ■

Projects

1. Systemic Inflammation in Patients with Cachexia Associated with Cancer: Mechanisms and therapeutic strategies within a translation medicine-based approach (No. 12/50079-0); **Grant Mechanism** Thematic Project; **Principal Investigator** Marília Cerqueira Leite Seelander (USP); **Investment** R\$2,246,952.23.
2. Molecular Basis of Cachexia: Adipogenesis and extracellular matrix remodeling of white adipose tissue in patients with gastrointestinal cancer (No. 10/51078-1); **Grant Mechanism** Young Investigator; **Principal Investigator** Miguel Luiz Batista Jr. (UMC); **Investment** R\$910,407.63.

Scientific articles

- ANTUNES-CORREA, LM *et al.* Molecular basis for the improvement in muscle metaboreflex and mechanoreflex control in exercise-trained humans with chronic heart failure. *American Journal of Physiology*. v. 307, i. 11, p. 1655-66. 2014.
- BATISTA, M. L. Jr., Cachexia-associated adipose tissue morphological rearrangement in gastrointestinal cancer patients. *Journal of Cachexia, Sarcopenia and Muscle*. v. 7, i. 1, p. 37-47. 2016.
- BELLOUM, Y. *et al.* Cancer-induced cardiac cachexia: Pathogenesis and impact of physical activity. *Oncology Reports*. v. 37, i. 5, p. 2543-52. 2017.
- BELUZI, M. *et al.* Pioglitazone treatment increases survival and prevents body weight loss in tumor-bearing animals: Possible anti-cachectic effect. *PLoS One*. v. 10, i. 3, p. 1-16. 2015.
- LIRA, F.S. *et al.* The therapeutic potential of exercise to treat cachexia. *Current Opinion in Supportive and Palliative Care*. v. 9, i. 4, p. 317-24. 2015.
- MOORE, S. C. *et al.* Association of leisure-time physical activity with risk of 26 types of cancer in 1.44 million adults. *JAMA Internal Medicine*. v. 176, i. 6, p. 816-25. 2016.
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Breaking boundaries

Real-time genome sequencing reconstructs the trajectory of Zika virus across the Americas

Maria Guimarães and Karina Toledo (of Agência FAPESP)

PUBLISHED IN JUNE 2017

Zika reached Northeast Brazil one and a half years before it was recognized as a public threat, according to two articles written by different groups and published online in the journal *Nature* on May 24, 2017. The virus spread quickly, taking advantage of *Aedes aegypti* mosquitoes and a human population that had virtually no immunity to it. It also disguised itself as dengue and chikungunya, illnesses that present similar symptoms. Researchers working in parallel relied on different resources but shared a common goal: to monitor the evolution of the viral genome not only to understand what was happening but also to predict new outbreaks and keep diagnostic methods up to date.

A portion of these findings come from ZiBRA, the Zika in Brazil Real-Time Analysis Project. Using a mobile lab equipped with a genome sequencing device that fits in the palm of the hand, an international team has been investigating the path of the Zika virus ever since it landed in Brazil and began spreading across the Americas (see Pesquisa FAPESP Issue No. 239). They have made the entire genome sequence avail-

able to other research teams, broadening the scope of the work. “By combining epidemiological and genetic data, we were able to see that Zika was silently circulating in all regions of the Americas at least a year before its presence was first confirmed, in May 2015,” says Portuguese-born Nuno Faria, a physician-scientist at the University of Oxford and the first author of the article that describes the results of the 2016 monitoring efforts.

According to Faria, the virus was introduced into Northeast Brazil in February 2014. There was likely some low-level transmission in the region that year but nothing very significant. “The major outbreak most likely took place in 2015, concurrent with the dengue outbreak. Zika spread from Northeast Brazil to the Southeast region [where it first struck Rio de Janeiro] and to the Caribbean and other countries in South and Central America, eventually reaching Florida,” he says.

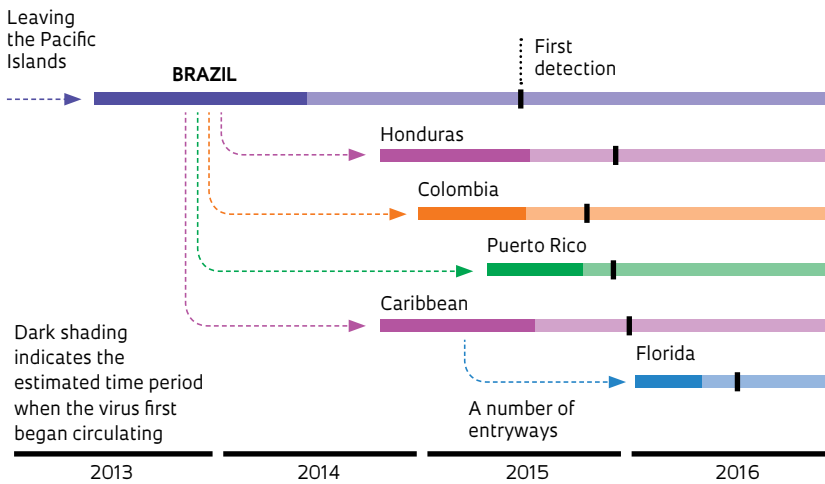
The ZiBRA Project based its conclusions on the analysis of 254 whole genome sequences of the pathogen, 54 of which were sequenced for the study published in *Nature*. Most of this new

genetic data was obtained using MinION, a portable sequencer weighing less than 100 grams that is manufactured by Oxford Nanopore Technologies. The protocols that enabled the use of this technology to sequence the Zika virus were designed as part of the ZiBRA Project and eventually gave rise to a second article, published online by *Nature Protocols* on the same date. This method was adapted to the virus circulating in Brazil at the Institute of Tropical Medicine of the University of São Paulo (IMT-USP), under the leadership of epidemiologist Ester Sabino and in partnership with collaborators from the University of Birmingham, in the United Kingdom. “Our intern Ingra Claro tested the samples according to instructions from Joshua [Quick, first author of the article on the method] in order to obtain enough viral RNA,” Sabino explains.

The greater the number of sequences generated, Sabino adds, the easier it is to understand when the virus entered Brazil, how it spread across the continent, and mainly, how it is evolving. This analysis is possible thanks to the molecular clock technique, which evalu-

Fast, subtle migration

In all of the countries affected by the disease, starting in Northeast Brazil, it was months before Zika was detected



SOURCE WOROBEBY, NATURE



ates the accumulation of mutations to certain genes. These changes occur at a relatively constant rate and the genes serve as timers that indicate how long it has been since the viral isolates diverged.

LABORATORY ON THE ROAD

“The idea for the project emerged in 2016 when part of the group published the first epidemiological and genetic findings on Zika in the Americas in *Science*. We had sequenced seven viral isolates, but the number of samples wasn’t enough to provide a broad notion of the virus’s diversity on the continent,” says geneticist Luiz Carlos Alcântara, of the Oswaldo Cruz Foundation (Fiocruz) in Bahia.

The ZiBRA Project was approved as a result of a call for proposals issued jointly by three British research funding agencies: the Medical Research Council, the Newton Fund, and Wellcome Trust. Researchers from a number of institutions have joined in the initiative, including Fiocruz, the Evandro Chagas Institute, Brazil’s Ministry of Health, USP, and the Birmingham and Oxford universities.

During 2016, a lab installed on a bus visited Central Public Health Laborato-

Set up on a bus, the mobile lab visited the states of Rio Grande do Norte, Paraíba, Pernambuco, and Alagoas in 2016

ries (LACEN) in the states of Rio Grande do Norte, Paraíba, Pernambuco, and Alagoas. Other leaders of the initiative, alongside Alcântara, Faria, and Sabino, were researchers Nicholas Loman, Oliver Pybus, of the University of Birmingham, and Marcio Nunes, of the Evandro Chagas Institute in Pará. “At each Central Lab,

we analyzed 300 to 400 blood samples from patients with suspected Zika, performing a total of 1,330 tests. We did real-time diagnosis, and when the results were positive, the virus’s genetic material was sequenced,” reports Alcântara.

With support from fixed laboratories at Fiocruz, in Salvador, Bahia, and at IMT-USP in São Paulo, the team also analyzed samples from Southeast Brazil and the state of Tocantins. Collaborators in the United States sequenced the genomes of four viral isolates from Mexico and five from Colombia. “The analyses showed that, up until 2016, the viruses found in the various regions of Brazil and neighboring Latin American countries were not yet displaying much diversity,” says Alcântara.

According to Alcântara, the African strain reached Asia shortly before 2007, when it triggered the first epidemic in Micronesia. Further outbreaks were recorded in the Philippines (2012) and French Polynesia (2013 and 2014). Zika next struck Brazil, which has reported the largest number of cases to date, surpassing 200,000 by December 2016. “The virus has changed a lot since leav-

Jaqueline Goes de Jesus, of Fiocruz, and Nuno Faria use a handheld MinION to monitor Zika in João Pessoa, Paraíba



ing Africa. Seven to 10 years from now, there will probably be much more diversity here in the Americas. We have to maintain genomic surveillance so we are prepared if a new outbreak comes,” advises Alcântara.

In addition to assisting Central Labs to diagnose hundreds of suspected Zika cases, ZiBRA researchers also trained teams to conduct genomic surveillance using MinION. The second stage of the project is now underway, which involves monitoring the dengue, chikungunya, and yellow fever viruses, in addition to Zika. “We’re going to set up a fixed lab in Manaus to analyze Central Lab samples from Amapá, Acre, Amazonas, Roraima, and Rondônia. In October 2017, we’re taking a mobile lab to the Central-West, and in March 2018, we’ll head to the Southeast,” says Alcântara.

MONITORING FROM A LAB BENCH

Real-time monitoring is also the focus of the efforts of another international group, although it performs its genetic analyses in fixed laboratories. The team used some of the same procedures but combined the protocols developed for MinION with the use of more powerful devices. “The focuses were complementary,” says geneticist Bronwyn MacInnis, of the Broad Institute in the United States. The study led by her in partnership with her colleague Pardis Sabeti

The risk that researchers will be caught by surprise has decreased thanks to genetic surveillance and collaborative networks

involved sequencing 110 Zika genomes from samples collected in 10 countries. The fact that the two teams took different paths but reached similar conclusions lends support to their interpretations and validates the new sequencing techniques they have developed, which in turn provides new strategies for tracking epidemics.

One challenge faced by both groups is that the Zika virus typically presents a low viral load or viremia. “By the time the patient seeks help, the infection is

already going away,” says MacInnis. In her earlier experience, during the Ebola outbreak that hit Africa in 2015, she found 1,000 to 10,000 times more viral copies in samples drawn from patients. Despite this difference, training with Ebola was the preliminary step that enabled MacInnis and her collaborators to plunge into researching the Zika epidemic without even having time to catch their breath. “That was the first time that genetic monitoring of an epidemic occurred in real time,” she says. Prior to that, samples had to be collected from patients and cultured in a laboratory in order to obtain enough virus for testing. The problem is that not everything present in the sample will grow in culture, and as a result, a great deal of diversity is lost in this process. The novel feat accomplished by the newer techniques was managing to perform genetic analyses directly on blood drawn from patients, using techniques that capture the genetic material—RNA in the case of Zika—directly from the sample.

When the epidemic broke out in Brazil and other countries in South America and the Caribbean, MacInnis looked for partners in Brazil with whom to exchange knowledge. She forged what she describes as a rich collaborative relationship with Fernando Bozza, Thiago Souza, and Patricia Bozza, all at Fiocruz in Rio. “They brought an understanding of how



In Natal, Marta Giovanetti, of Fiocruz, prepares sequencing (*left*); examining mosquitoes captured in that city

the disease was progressing and how it interacted with the viruses that cause dengue and chikungunya,” she says.

The group from Rio de Janeiro had already acquired an epidemiologic understanding of dengue by working with hospitals and conducting systematic surveillance of the disease. “Zika required a lot of work in the beginning because of the low viremia,” recalls Fernando Bozza. After successfully developing a quick diagnostic test, his team began collecting samples and working to improve their success in extracting RNA, which required the enforcement of more rigorous methods of collecting and storing the material.

Bozza believes that the delay in the identification of Zika after it entered Brazil underscores the importance of genetically monitoring relevant diseases that have already been detected on other continents. “By the time we identified the problem, an epidemic was already underway.” If researchers understand the evolution of the virus and possess surveillance techniques, they can develop strategies for detecting diseases faster.

Genetic data indicate that it was months before the first cases of the virus were detected in Puerto Rico, Honduras, Colombia, and areas of the Caribbean and the United States. Its subtle circulation allowed Zika to move from the Caribbean into the United States, as reported in a fourth article, also published online in *Nature* on May 24, 2017. However, Florida is the only state where conditions are suitable for *Aedes aegypti* to remain year-round, allowing the virus to spread. The disease has thus been confined to that state, particularly to the Miami region, a destination for large numbers of visitors from abroad. “The virus was introduced many times. It wasn’t an isolated event,” asserts MacInnis, coauthor of the paper. “Understanding how this happened is important in coordinating our efforts to control the vector and protect entry routes.”

MacInnis knows that while there may be a break in the action now, before summer comes to Florida, other epidemics will follow. For the time being, the Zika virus still presents a bit of a mystery—it circulated less than expected during Bra-

zil’s previous summer. “We’re going to continue monitoring to try to understand how the virus advances,” says Sabino, whose team has been tracking donated blood samples at four major blood banks in São Paulo. “We’re learning ways to put together research groups that can respond quickly in an emergency.” The risk that researchers will be caught by surprise has decreased as genetic surveillance and collaborative networks have acquired new knowledge. These simultaneous publications drive home the fact that addressing epidemics depends vitally on teamwork that draws in experts from different fields. The two groups working in parallel were aware of this and therefore did not close themselves off. “We kept in touch throughout the process, comparing our findings,” says MacInnis. ■

Project

Complete genomes for dengue virus: viral genetic diversity among seropositive first-time blood donors and recipients in two blood centres in Brazil (No. 12/03417-7); **Grant Mechanism** Scholarships in Brazil - Doctorate; **Principal Investigator** Ester Cerdeira Sabino (USP); **Grantee** Antonio Charlys da Costa; **Investment** R\$145,246.14.

Scientific articles

FARIA, N. R. *et al.* Establishment and cryptic transmission of Zika virus in Brazil and the Americas. *Nature*. v. 546, i. 7658, p. 406-10. June 15, 2017.
GRUBAUGH, N. D. *et al.* Genomic epidemiology reveals multiple introductions of Zika virus into the United States. *Nature*. v. 546, i. 7658, p. 401-05. June 15, 2017.
METSKY, H. C. *et al.* Zika virus evolution and spread in the Americas. *Nature*. v. 546, i. 7658, p. 411-15. June 15, 2017.
QUICK, J. *et al.* Multiplex PCR method for MinION and Illumina sequencing of Zika and other virus genomes directly from clinical samples. *Nature Protocols*. v. 12, i. 6, p. 1261-76. May 24, 2017.

Natural lighting

The chemical process underlying the bioluminescence of mushrooms is recyclable and flexible



The green light emitted by *Neonothopanus gardneri* is visible on dark nights

PUBLISHED IN MAY 2017

A street illuminated by bright trees, instead of light posts. This sounds like the makings of a dream but does not seem to be impossible to chemist Cassius Stevani, a professor at the University of São Paulo Chemistry Institute (IQ-USP). “But we have to be careful, as we do not want the natural forest to emit light at night,” he warns. Although it is beyond the realm of reality, this science fiction-inspired scenario is based on Stevani’s research on bioluminescent mushrooms, principally the species *Neonothopanus gardneri*, which grows in the Mata dos Cocais forest in the state of Piauí (see *Pesquisa FAPESP Issue No. 168*). He and a number of collaborators, mostly in Russia and Brazil, have just unlocked the mystery behind an important part of the chemical reaction that gives these mushrooms their green glow, as reported

in the article published on April 26, 2017 in the journal *Science Advances*.

An important contribution of the research was discovering that hispidine, a molecule with pharmacological properties that is found in most plants, is a precursor of luciferin, a substrate that is essential for light production in mushrooms. Hispidine is also found in non-luminescent mushrooms, in which it is responsible for their orange color and for protecting them against damage caused by sunlight.

According to the sequence of chemical reactions demonstrated by the group of researchers, luciferin reacts with oxygen via the action of the enzyme luciferase and produces excited oxyluciferin, which, when it decays into the ground state, emits a photon—and therefore light. The oxyluciferin is then converted into caffeic acid through the action of another enzyme. This is another im-

portant finding because caffeic acid was already known to be a precursor of hispidine. Stevani explains that this is how the cycle comes full circle: “The molecules involved in bioluminescence are recycled, which explains the small amount of hispidine that is found in mushrooms: it is constantly being formed, converted, and then recycled – in this way, the bioluminescence cycle continues.” As this process consumes oxygen, it could also provide a way for the mushroom to minimize damage from oxidative stress.

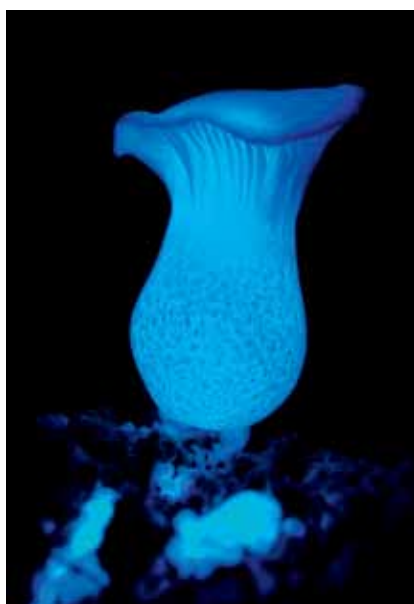
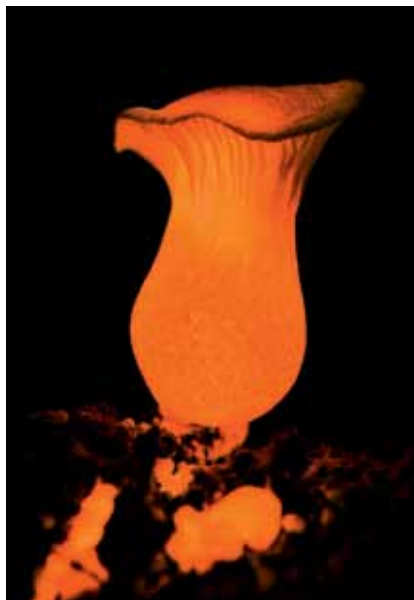
Trees and other plants also produce caffeic acid, and this is the source of the playful idea to use genetic manipulation to give them the ability to produce the enzymes needed to complete the reaction and glow; “Luminescent orchids could also be produced for the ornamental plant market,” the chemist suggests. U.S. biochemist Hans Waldenmaier, who

These altered images illustrate what the mushroom would look like if it produced alternative substrates

completed his doctorate under Stevani in 2016, plans to set up a company to produce bioluminescent plants in the United States. The goal is not just decorative. “Maybe one day it will be possible to use this system as a reporter for the biological processes of plants and apply the knowledge to human health problems,” says the IQ-USP professor. The use of fluorescent proteins as genetic markers, or reporters, earned Osamu Shimomura, Roger Tsien and Martin Chalfie the 2008 Nobel Prize for Chemistry, precisely because of the importance of this method in visualizing biochemical processes. In their case, a fluorescent protein produced by jellyfish was used, which is widely used in laboratories around the world.

PRODUCTIVE CHEMISTRY

The results reported in the *Science Advances* article arose from the collaboration between Stevani and the Russian chemist Ilia Yampolsky of the Institute of Bio-organic Chemistry in Moscow, a partnership that emerged in an unusual way. When Stevani learned from students coming back from an international congress that Yampolsky was looking to characterize the molecules responsible for bioluminescence in mushrooms, the Brazilian researcher contacted him to propose working together; however, he contacted him too late. The results of the study had already been submitted for publication, based on a mushroom very similar to the Brazilian mushroom, *Neonothopanus nambi*, which grows in Vietnam. In the competitive world of academia, being scooped by a researcher who began working in the field only recently could be cause for spite and enmity. In fact, the opposite occurred. To obtain the results presented in *Science Advances*, each scientist contributed his expertise—for the Russian, it was in the synthesis of organic compounds, and for the Brazilian, it was in chemical mechanisms. In São Paulo, others also contributed – chemists Erick Bastos and Paolo di Mascio of the IQ, Anderson Oliveira of the Oceanographic Institute, and phar-



macists Felipe Dörr and Ernani Pinto of the School of Pharmaceutical Sciences, all of whom are at USP.

In addition to clarifying which molecules contribute to the bioluminescence reaction, the researchers found that luciferase is versatile. Yampolsky synthesized variations of luciferin that, upon reacting with luciferase, also generate light. As these molecules are not naturally produced by the mushrooms, the reaction was produced inside an apparatus, known as the luminometer, which detected the presence of light. The key difference is that the light produced in this way would have a wavelength different from the green observed in nature. If the reaction did occur in nature, the mushrooms would emit other colors, such as those shown in the altered images that accompany this article: “poetic license”, in the words of the Brazilian chemist.

From pure chemistry to fiction and technological applications, Stevani also dabbles in biology by way of his investigations into the ecological significance of mushroom luminescence. The results obtained by Waldenmaier for his doctoral thesis are still being prepared for publication, but it can already be said that the field experiments he conducted and the accompanying videos suggest that brightness attracts insects and leads to the creation of a unique miniature ecosystem. Mushrooms appear to be a meeting point for fireflies, who usually visit them in pairs. Bush cockroaches (*Ellipsidion humerale*) eat the mushrooms and are hunted by spiders. All of them, Stevani suggests, are attracted by the light that spreads much farther than scent in the forest environment. While this is all happening, animals become covered with spores and help spread the mushrooms. Since they grow near the ground where it is more humid, there is no wind to disperse their reproductive spores. Through collaboration, everyone wins. ■

Maria Guimarães

Project

Fungal bioluminescence: species survey, mechanistic study & toxicological assays (No. 13/16885-1); Grant Mechanism Regular Research Grant; Principal Investigator Cassius Vinicius Stevani (USP); Investment R\$ 183,183.40 + US\$ 58,141.94.

Scientific article

KASKOVA, Z. M. *et al.* Mechanism and color modulation of fungal bioluminescence. *Science Advances*. April 26, 2017.



Elacatinus phthirophagus (yellow and black) cleaning *Cephalopholis fulva*

Deep sea alliances

Six species of cleaner fish from the Rocas Atoll obtain food by removing parasites from larger fish

PUBLISHED IN AUGUST 2017

The waters of the Rocas Atoll, 267 km from Natal, Rio Grande do Norte State in Brazil, are home to one of the most striking phenomena seen in coral reefs: when predatory fish give themselves moments of respite and receive cleaning services from other fish and shrimp. In one of the most extensive surveys ever performed on the atoll, biologists from the Federal University of Santa Catarina (UFSC) identified eight cleaners—six fish and two species of shrimp—within the biological conservation area. The region is closed to the public and covers an area of 5.5 square kilometers (km²).

Cleaner fish specialize in eating parasites, diseased tissues, or mucus from larger fish and turtles, species that experts refer to as the *clients* of cleaner fish. “As a result of these interactions, clients maintain their health and the cleaner gets food, but both sides have had to evolve to recognize each other and to not attack each other during the cleaning process,” summarizes Colombian biologist Juan Pablo Quimbayo Agreda, a researcher from UFSC. He is part of the Brazilian Marine Biodiversity Research

Network (SISBIOTA-MAR), which has brought together 30 researchers from nine institutions in order to study the biodiversity of Brazil's four oceanic islands: the Rocas Atoll, the Fernando de Noronha Archipelago, the São Pedro and São Paulo Archipelago, and the Trindade and Martim Vaz Archipelago.

“Cleaner fish evolved from other fish that ate small crustaceans and other invertebrates,” says biologist Carlos Ferreira, a professor at Fluminense Federal University (UFF) and one of the coordinators of SISBIOTA-MAR. He explains that by specializing in eating parasites, a relatively scarce food source, fish that spend most of their lives in reefs “avoid competition for other foods.”

In May 2016, under the guidance of Ferreira and biologists Sérgio Floeter of UFSC and Ivan Sazima of the University of Campinas (UNICAMP), Quimbayo and biologists Lucas Nunes and Renan Ozekoski, also from SISBIOTA-MAR, observed 318 interactions between fish at depths ranging from 1 meter (m) to 5 m for 44 hours over 22 days.

Two species endemic to the region were the most active: the Noronha wrasse (*Thalassoma noronhanum*), which reaches 12 cm in adulthood, and the Noronha cleaner goby (*Elacatinus phthirophagus*), which can reach up to 4 cm. The wrasse participated in 75% of the cleanings and

In the atoll, the wrasse prefers herbivorous clients and avoids predators, who may eat it if its cleaning services are not well rendered

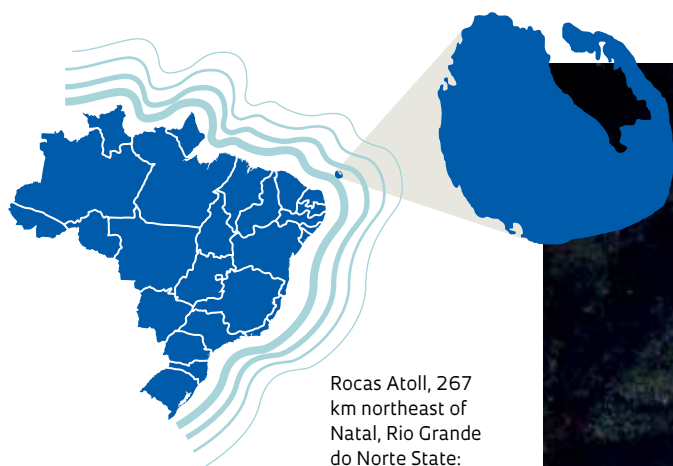
The *Lysmata shrimp* with white antennae between the ventral fins of a *Holocentrus*

served the largest variety of client species: 18 of the 22 total fish species and one turtle species that sought the cleaners' services. In an article published this July in the journal *Environmental Biology of Fishes*, the biologists attribute the high number of cleaning sessions to the fact that most of the clients (82%) are herbivores; it is important to note that the wrasse was also found to be the most abundant species in the area.

The three biologists observed peculiar behaviors among the cleaner fish in the atoll. Around Fernando de Noronha, only juvenile wrasses feed on the parasites of other fish, but in the atoll, this habit is also maintained by adults. In the atoll, the wrasses avoid getting too close to species that could eat them. “We assume that this species can somehow identify which species are dangerous—probably through an evolutionary process that eliminated more reckless individuals,” says Quimbayo.

The goby was found to have a flexible diet, abandoning the herbivorous habits it maintains in other places; in the atoll, it feeds on worms, even risking its life by approaching carnivorous clients such as nurse sharks (*Ginglymostoma cirratum*), which can grow to as much as 4 m in length and 100 kg in weight. In a study from August 2010 to April 2015 around Malpelo Island, located 400 km west of





Rocas Atoll, 267 km northeast of Natal, Rio Grande do Norte State: eight cleaner species among the reefs



Pomacanthus paru (black with yellow stripes) performing its cleaning services on an *Acanthurus*

the Colombian coast, Quimbayo identified five species of fish acting as cleaners, none of which specialized in this activity as much as those in the atoll. In just over half (56%) of the 120 interactions, the clients were predatory species such as groupers, stingrays, and sharks.

CLEANING SERVICES

More clients frequent cleaners early and late in the day; the cleanings can last from a few seconds to several minutes. Cleaning sessions usually take place in specific spaces, known as “cleaning stations,” which are located near rocks or coral, and the fish follow their own rituals (see Pesquisa FAPESP, issue No. 79). Clients enter the cleaning stations and exhibit more vivid colors or swim face down to indicate that they will allow for a cleaning and will not attack. “They are in a buffer zone; nobody is going to eat anybody,” reports Quimbayo. Through his observations, he has determined that cleaner fish should be careful so as not to risk being eaten during the cleaning service. “If the cleaner fish chews off a piece of skin or mucus, the client may not like it and may react with a sharp bite.”

There are 208 cleaner fish species circulating in and around the bays and islands of the world. They make up approximately 3% of the 6,500 species of reef fish and less than 1% of the world’s 30,000 fish species, according to a survey organized by David Brendan Vaughan of James Cook University in Australia, published in 2016 in the journal *Fish and Fisheries*. Cleaner shrimp are even less common. Of the 51 known species, two

live in the atoll: *Lysmata grabhami*, with white antennae up to 6 cm in length, and *Stenopus hispidus*, with a red-and-white-striped body and white antennae that grows up to 10 cm in length. They accounted for only 3.7% and 2.7% of all recorded cleaning episodes, respectively, and offered services mainly when cleaner fish were not around. These observations were similar to Quimbayo’s previous findings in a 2012 study on the islands of Cape Verde and São Tomé and Príncipe off the coast of Africa.

ISLANDS AT RISK

The SISBIOTA-MAR surveys indicate that the Rocas Atoll is the most well preserved of the four Brazilian oceanic islands since it is a biological reserve with access granted only to researchers. “Even in Fernando de Noronha, which has the status of a national park, the protected area sustains a growing human

population, and there is an area outside the park where activities such as fishing are allowed,” Ferreira notes. He also explains that the fish in the protected area can swim to the unprotected area where they are caught.

Ferreira notes that in the São Pedro and São Paulo Archipelago, located 1,000 km from Natal, there are no longer any sharks, and schools of tuna have been greatly reduced due to overfishing. In recent years, the island of Trindade, located 1,200 km east of Vitória, Espírito Santo State, has suffered from underwater fishing “because it has no protection status,” he explains. In August of this year, on the fifth expedition for the project, the SISBIOTA-MAR team intends to return to Trindade for their annual monitoring of marine organism communities. ■ Carlos Fioravanti

Scientific articles

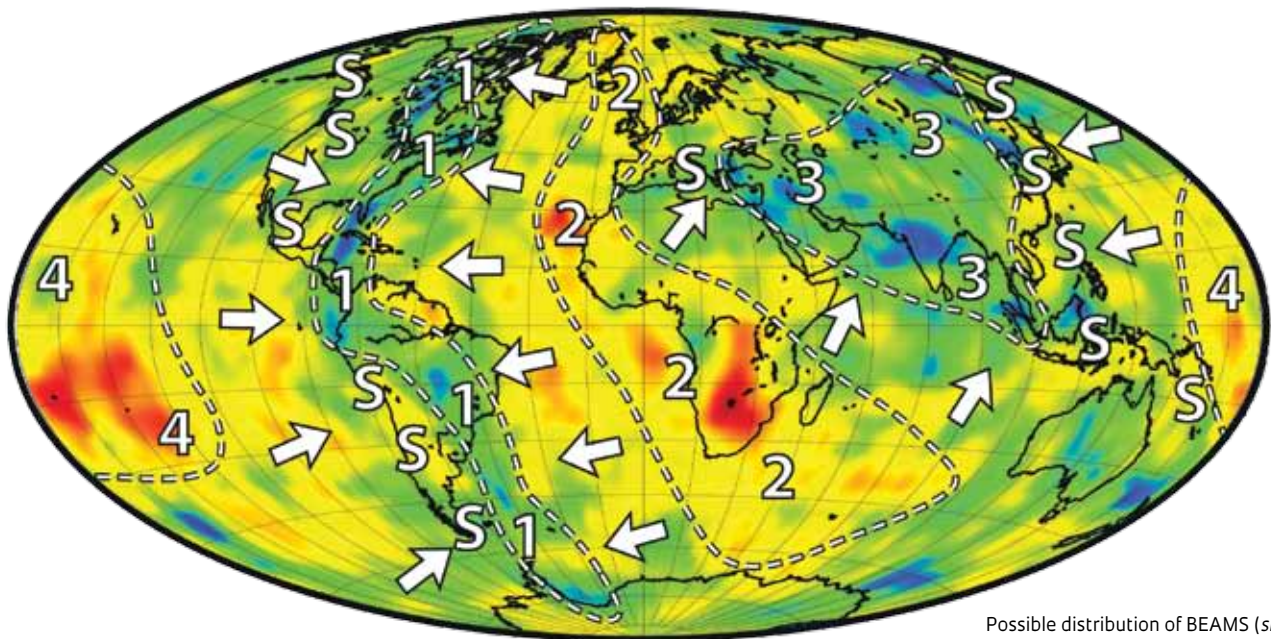
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Vestiges of primitive Earth

The depths of the Earth may contain rigid blocks spanning thousands of kilometers

PUBLISHED IN MAY 2017



Possible distribution of BEAMS (shown in yellow), areas of plume concentrations (in red, regions 2 and 4) and sinking tectonic plates (in blue, regions 1 and 3). The arrows indicate the direction of mantle movement; S denotes plates that have stopped sinking

The Earth's interior is believed to contain immense blocks of rock. Because these rocks are denser and more rigid than the material around them, they likely stabilize the movements of the mantle, i.e., the layer between the Earth's surface and core, which comprises approximately 80% of the planet's volume. Known as bridgmanite-enriched ancient mantle structures, or BEAMS, these blocks are thought to span thousands of kilometers (km), lie at least 1,000 km deep and float on the lower mantle, near the boundary of the Earth's core almost 2,900 km below the surface.

A team of researchers from the Tokyo Institute of Technology and the Swiss Federal Institute of Technology Zurich (ETH Zürich), along with Brazilian physicist Renata Wentzcovitch of Columbia University in the United States, proposed this new hypothesis about the composition and mechanics of the lower mantle in a study published in *Nature Geoscience* on February 27, 2017. Although not considered complete, this hypothesis explains a number of phenomena, such as the upwelling of less dense rocky material from the mantle to the surface and the sinking trajectory of the edges of tectonic plates formed by

the crust and upper mantle in the planet's interior. Both of these phenomena might occur in the less viscous regions between BEAMS.

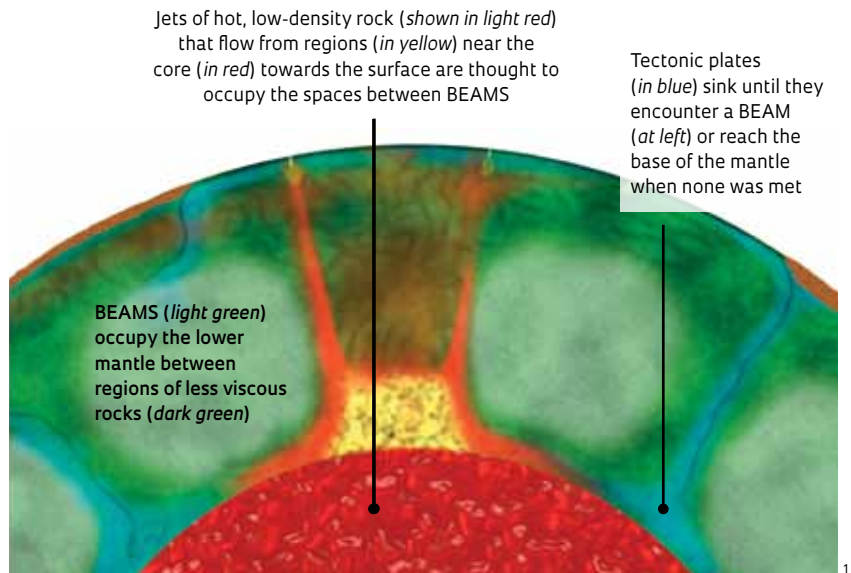
The above mentioned researchers developed this hypothesis based on two pieces of evidence about the composition of the mantle. The first piece was obtained indirectly with tomographic models, which indicate the consistency of the planet's interior based on changes in the velocity of seismic waves. These waves, which are generated by earthquakes, pass through the interior of the planet at velocities that depend on the density and temperature of the material they traverse.

The second piece of evidence was obtained directly in the form of primitive meteorites called chondrites, which are rich in magnesium and silicon. Although these rocks came from space, they are likely the same material that formed the Earth's interior 4.5 billion years ago. The composition of this type of meteorite indicates that the lower mantle may be compositionally different from the next closest layer to the surface, i.e., the upper mantle. The outermost layer of the mantle begins immediately below the Earth's crust and extends 660 km downward, with rocks at temperatures that increase with depth and reach up to approximately 1,600 degrees Celsius (°C) at the boundary with the lower mantle. In the lower mantle, the rocks are denser and the temperature ranges from 1,600°C to 3,700°C at the boundary with the core.

The researchers confirmed that these indicators of the composition of the

Deep discoveries

BEAMS may explain the movements of tectonic plates towards the Earth's core



Earth's interior were not consistent with a hypothesis established in the 1960s; according to this hypothesis, the upper and lower mantles have the same composition. "The ratio between the amounts of magnesium and silicon in the Earth is likely the same as that of the Sun, because the two were formed from the same nebula," Wentzcovitch hypothesized. "The upper mantle contains 25% more magnesium than silicon, in the form of magnesium silicate (Mg_2SiO_3). If that ratio held true in the lower mantle, there would be less silicon on Earth than expected, based on the composition of the Sun or of chondrites."

In the study, the researchers assumed that the lower mantle has more silicon than the upper mantle, increased the proportion of this element and performed two-dimensional numerical computer simulations of the possible movements of that deep planetary layer. The simulations indicated that much of the mantle formed soon after the birth of the planet might remain to this day in the form of a mineral known as perovskite or bridgmanite ($MgSiO_3$), without mixing with the adjacent region formed by rocks with a 20 to 30 times lower viscosity. Consequently, the more viscous material, i.e., the BEAMS, could be vestiges of the planet's earliest existence. "Our simulations indicated that these rigid blocks did not become more liquid as the Earth evolved," explained Wentzcovitch, who has studied the possible processes involved in the formation and transformations of bridgmanite in the planet's interior (see *Pesquisa FAPESP Issue No. 198*). "The silicon that appears to be missing must be hidden in the lower mantle."

"We don't know how many BEAMS there are, but there probably aren't more than three or four," she noted. "Our next project will be to define them accurately, through a detailed analysis of the changes in velocity of seismic waves." Proving the existence of BEAMS is a very difficult



Chondritic meteorites such as this, which was found in northwestern Africa, help scientists better understand the composition of the Earth's lower mantle



An international team of scientists plans to use this vessel, the *Chikyu*, to drill into the Earth's crust to reach the mantle in 2030

task. In April 2017, an international group of scientists announced their plans to be the first to penetrate the mantle, probably in 2030, using the vessel *Chikyu* to drill to 11 km below the surface; this depth is still far above the 2,000 km level where silicon-rich blocks can be found.

The current hypothesis assumes that tectonic plates likely sink in the less viscous region between the BEAMS and extend down to the bottom of the mantle. The intriguing previously identified fact that some plates stopped at a depth of approximately 1,000 km might be explained by the possibility that they encountered a BEAM, which hindered subduction. Conversely, the material in the deep mantle could also rise to the surface through the regions between the rocky blocks.

This study also indicates that the BEAMS may determine the origin and trajectory of plumes, which are jets of hot, low-density rock, 100 to 200 km in diameter, that flow from the mantle-core boundary and rise to the surface, creating volcanic regions such as the archipelagos of Fernando de Noronha,

Hawaii and the Galápagos. On the basis of this hypothesis, the researchers produced a map showing the possible distribution of BEAMS and plume-rich regions concentrated in southern Africa and the central Pacific Ocean.

LIMITATIONS AND INTERACTIONS

In a comment published in the same issue of *Nature Geoscience*, geophysicist Frédéric Deschamps, a researcher at the Institute of Earth Sciences, Sinica Academy, Taiwan, noted that the BEAMS hypothesis may explain the movement of tectonic plates in mantle regions with lower viscosities and the locations of volcanic regions over the plumes. Nevertheless, he said that the two-dimensional model cannot fully describe the spatial heterogeneity of seismic wave velocity measurements at depths greater than 2,500 km. To better understand this situation, he suggests that “three-dimensional simulations would be needed.”

“The simulation presented in *Nature Geoscience* is one step further in our understanding of the lower mantle,” commented geophysicist Eder Molina, a professor at the Institute of Astronomy, Geophysics and Atmospheric Sciences at the University of São Paulo (IAG-USP). “The fact that modeling does not explain some tomography records may be due to the limitations of its having been done in

two dimensions rather than three, but it could also be a consequence of an error in the model or problems with seismic wave detection, which is not an infallible method.”

Physicist João Francisco Justo Filho, a professor at the USP Polytechnic School who has worked with Wentzcovitch since 2007 but was not involved in the research published in *Nature Geoscience*, observed, “The proposed geodynamic model is the simplest possible one for producing plausible results. There are, however, other chemical elements, such as iron, hydrogen and oxygen, that can change the viscosity of the mantle rocks, even in small proportions.” In a study published in 2013 in *Physical Review Letters*, Wentzcovitch, Justo and Zhongqing Wu of the University of Minnesota showed that increased pressure in the deepest layers of the Earth could alter the magnetism of iron, increase the viscosity of rocks containing bridgmanite and ferropericlase, another mineral, and promote the formation of BEAMS. ■

Carlos Fioravanti

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WU, Z. *et al.* Elastic anomalies in a spin-crossover system: Ferropericlase at lower mantle conditions. *Physical Review Letters*. v. 110, p. 228501. 2013.

The next project aim will be to define BEAMS via changes in the velocity of seismic waves

When vacuum is hot

Brazilian researchers propose an experiment to determine whether empty space can heat an accelerated object

Igor Zolnerkevic

PUBLISHED IN MAY 2017

Calculations performed by a group of theoretical physicists in São Paulo indicate that conducting an experiment that uses the current generation of particle accelerators could prove the existence of what is known as the Unruh effect, which was proposed more than 40 years ago. This phenomenon is characterized by radiation that is composed of elementary particles that can only be recorded by a body that is undergoing extreme acceleration. If the effect really exists, then empty space must be hotter for a hypothetical observer undergoing accelerated movement than for a traveler moving at a constant velocity. In the latter case, the temperature of the vacuum is absolute zero. According to the calculations of the team composed of physicist George Matsas and his PhD student Gabriel Cozzella of São Paulo State University (Unesp) and physicists André Landulfo of the Federal University of the ABC (UFABC) and Daniel Vanzella of University of São Paulo (USP), the heat generated by the Unruh effect could be seen as radiation emitted by electrons accelerated in a laboratory.

The team's work suggests that the Unruh effect could be observed when a cloud of electrons emitted by a particle accelerator is rapidly decelerated inside

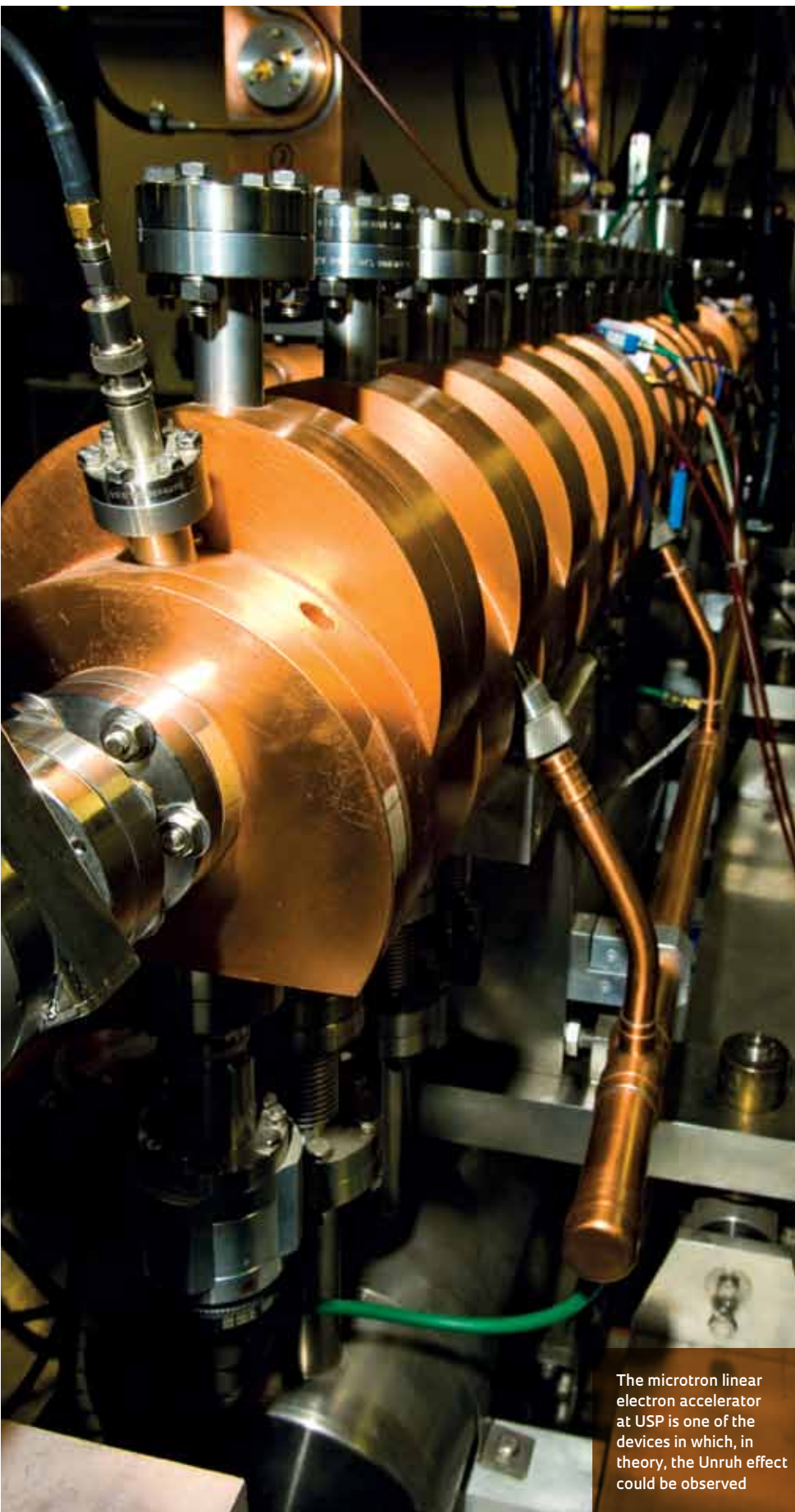
a tube due to the presence of strong electric and magnetic fields. Both force fields would oppose the direction in which the cloud is moving. This situation would cause the electrons to decelerate and follow a spiral trajectory while emitting light at various frequencies. They believe the effect is encoded in the radiation emitted by these electrons, as a type of signature. "If the Unruh effect does not exist, there will be an impact on the radiation emitted by electrons for lower frequencies, challenging the "sacred" predictions of classical 19th century electrodynamics," says Matsas who, together with Cozzella, Landulfo and Vanzella, wrote a scientific article published on April 21, 2017 in *Physical Review Letters*, in which they defend the feasibility of the experiment. The proposal is contrary to the beliefs of some physicists who are skeptical with respect to the possibility of confirming the effect experimentally using instruments that employ current technology.

If the idea is shown to be feasible, then the existence of the hypothetical phenomenon could be proven in Brazil, in theory. "I am still not convinced of the feasibility of the experiment," says experimental physicist Marcos Martins, coordinator of the microtron linear elec-

tron accelerator laboratory at USP, with whom the theoretical group is discussing the possibility of testing for the phenomenon. "The Unruh effect would appear in the radiation of the electrons in the MHz frequency, in the same band as signals emitted by radio and TV stations, but at a very low intensity, which could make it impossible to detect."

AVALANCHE OF PARTICLES

The existence of the effect was proposed in 1976 by theoretical physicist William Unruh of the University of British Columbia in Canada. Unruh imagined an elementary particle detector moving with great acceleration. Traveling along a straight line in completely empty space, one would expect that the highly accelerated particle detector would record the same number of particles that it would record if it were not moving: zero. The Canadian's calculations, however, showed that the accelerated detector would record an avalanche of elementary particles appearing in space out of nothing. The greater the acceleration of the detector, the hotter the pool of particles in which the detector would be immersed. The effect discovered by Unruh completed previous studies by U.S. mathematician Stephen Fulling and clarified the results



The microtron linear electron accelerator at USP is one of the devices in which, in theory, the Unruh effect could be observed

obtained independently during the same period by Australian Paul Davies.

The conclusion of Fulling, Davies and Unruh was a direct consequence of one of the best-tested hypotheses in physics, quantum field theory, which is the basis of the standard model, the set of mathematical formulas and rules that describe the behavior of all known elementary particles. The basis of quantum field theory, proposed by different physicists from the 1920s–1940s, combines the principles of Einstein’s specific theory of relativity and quantum mechanics.

Most physicists who investigate the consequences of the Unruh effect are convinced that the phenomenon must exist if quantum field theory is completely correct. One of the results that demonstrate this necessity was obtained by Matsas and Vanzella in 2001. These two investigators confirmed that the lifetime of a proton subject to extreme acceleration could only be calculated correctly when the Unruh effect is accounted for (see *Pesquisa FAPESP Issue No. 69*). However, not everyone is convinced. Some theoreticians, such as Vladimir Belinski at the International Center for Relativistic Astrophysics in Italy, argue that there is a mathematical error in the deduction of the effect, a complaint addressed by Unruh and others. “We hope that the experiment convinces the skeptics regarding the coherence of the Unruh effect,” said Fulling to the journal *Science* when commenting on the proposal by the physicists from São Paulo.

Both sides of the debate agree that the radiation predicted by the Unruh effect has not been observed because it is normally too weak. “To effectively create a pool of elementary particles at a temperature of 1 Kelvin (-272°C), one would have to build a probe capable of withstanding acceleration billions and billions of times greater than that withstood by current rockets,” comments Cozzella, first author of the article. ■

Project

Gravitation and quantum field theory (No. 15/22482-2); **Grant Mechanism** Regular Research Grant; **Principal Investigator** George Matsas (Unesp); **Investment** R\$31,879.15.

Scientific article

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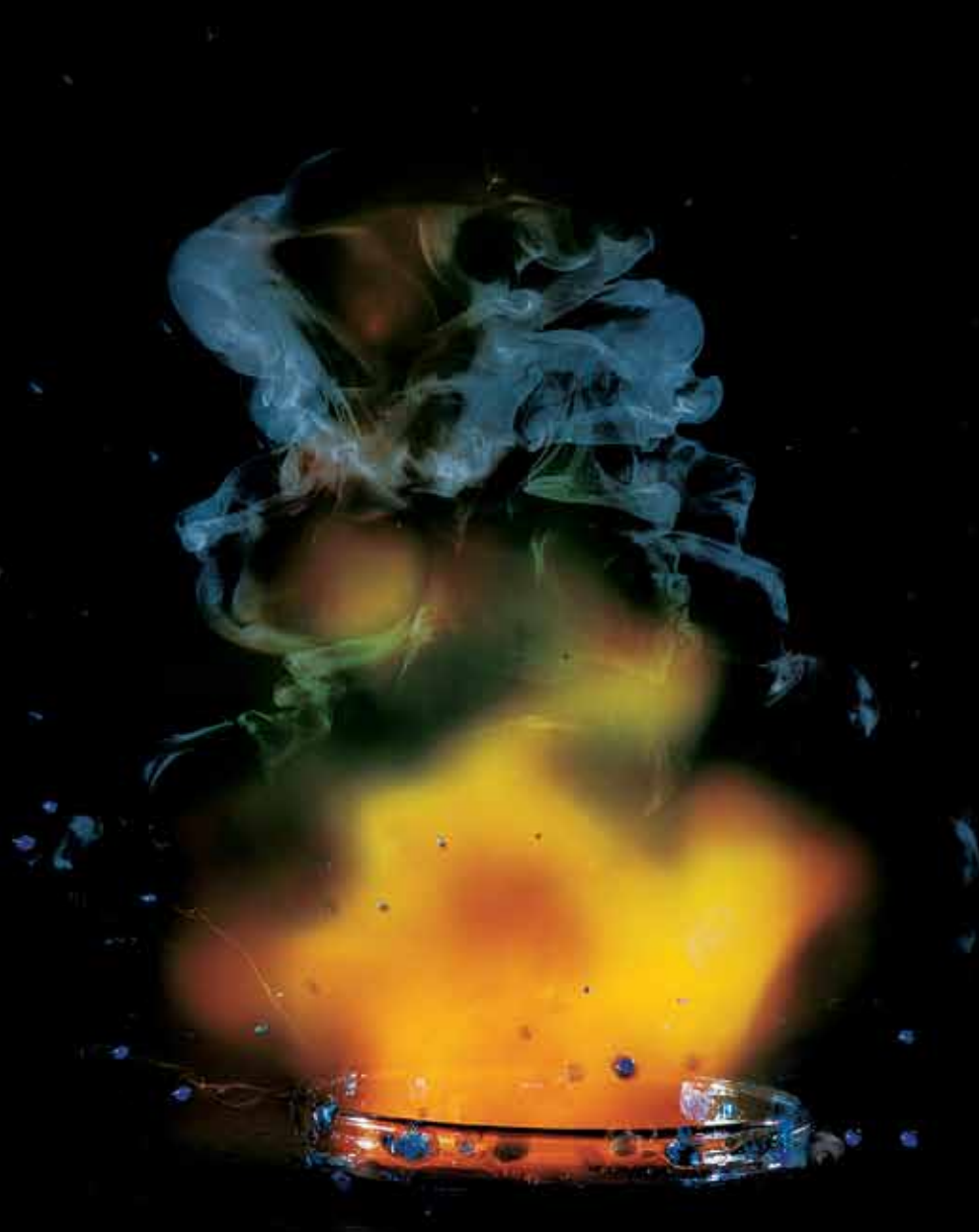


Green propulsion

INPE and the Brazilian Air Force develop sustainable engine and fuel for use in rockets and satellites

Yuri Vasconcelos

PUBLISHED IN JUNE 2017



Chemical reaction between a drop of hydrogen peroxide and the fuel composed of ethanol, ethanolamine and copper salts. The temperature reaches 900°C, and the gases can propel a satellite into orbit. The experiment was carried out at INPE, in Cachoeira Paulista.

Employing a renewable fuel for rockets and satellites that is less toxic, less harmful to human health and more environmentally friendly is the objective of two Brazilian research groups, one at the National Institute for Space Research (INPE) and the other at the Aeronautics and Space Institute (IAE), the research branch of the Aerospace Science and Technology Department (DCTA) of the Brazilian Air Force. At INPE, scientists in the Associated Laboratory for Combustion and Propulsion (LCP), in the city of Cachoeira Paulista, São Paulo State, developed a new space fuel, also called a propellant, whose ingredients include ethanol and hydrogen peroxide. One distinguishing feature of the fuel is that it does

not need an ignition source, such as a spark, to combust and make the engine work. At IAE, in São José dos Campos, the research was carried out together with the German Aerospace Center (DLR), whose focus is the development of an engine for vehicles to launch satellites that can run on ethanol and liquid oxygen.

The main propellants used in rockets and satellites are hydrazine, which is the fuel, and dinitrogen tetroxide, which is the substance that causes the burning reaction. These substances perform well in thrusters but have disadvantages. In addition to being expensive, hydrazine and its derivatives are carcinogenic and therefore require great care in handling. Dinitrogen tetroxide, however, can be fatal af-



Model of the L75 rocket developed at IAE, which uses ethanol and liquid oxygen

ter a few minutes of exposure, in the event of leakage or poor handling.

The search for an alternative space fuel that is less harmful to human health and the environment is not exclusive to Brazilian institutions. “Space agencies from several countries—including NASA—are conducting research on this topic [see sidebar below],” says Carlos Alberto Gurgel

Veras, director of the Brazilian Space Agency’s (AEB) Division of Satellites, Applications and Development. “Since Brazil has not mastered the production cycle for traditional propellants used in rocket engines, developing an alternative fuel would be a significant advance for the industry,” says Gurgel. Having a readily available fuel in Brazil, largely renewable and inexpensive, is part of the technological development package that the Brazilian aerospace industry aims to achieve. For more than 20 years, INPE has developed small satellites to collect environmental data and, together with China, to perform remote sensing with the goal of capturing images of Earth’s surface. All of these satellites were launched by foreign rockets.

Brazil has solid fuel propulsion engine technology for the small rockets used in scientific and technological experiments. “Our chief objective is to master the technologies needed to develop a liquid-propellant rocket engine. In order to launch large satellites, we have to use this type of propulsion,” says metallurgical engineer Daniel Soares de Almeida, IAE project manager.

Chemical engineer Thais Maia Araujo, a specialist in rocket fuels and a professor in the aerospace engineering course at the Federal University of the ABC (UFABC) in São Bernardo do Campo, São Paulo State, says that it is important for Brazil to work on developing a renewable propellant for the industry. “The fuel being developed at INPE, in addition to being safer and easier to handle, is cheaper than traditional

Alternatives around the world

NASA and ESA have propellant projects that could be advantageous replacements for hydrazine

Before the end of 2017, the North American Space Agency (NASA) plans to test a propellant that would be an alternative to the traditional rocket fuel hydrazine. Named AF-M315E, it is an ammonium-nitrate-based liquid, a substance that is easier to obtain and less dangerous to handle than hydrazine. Since 2012, NASA’s Green Propellant Infusion Mission program has partnered with the U.S. Air Force Research Laboratory, which is responsible for developing the fuel, and U.S. companies Aerojet Rocketdyne, which designed the thruster, and Ball Aerospace & Technology, which is managing

the project. According to Ball, the new propellant performs almost 50% better than systems using hydrazine. With this improvement, the same tank can carry a larger amount of AF-M315E, in theory extending the duration of space missions.

The new propellant is considered green by the Americans because it has environmental benefits, such as being less toxic than hydrazine. It will be used to maneuver a small satellite in space. Over a period of 13 months, changes will be made in the altitude and orbital attitude of the satellite to demonstrate the feasibility of the propulsion system.

The European Space Agency (ESA) also has green fuel candidates. One project is on the monopropellant LMP-103S, developed by the Swedish company ECAPS, ESA’s partner. The main ingredient is a substance known as ammonium dinitramide (ADN), obtained using chemical processes whose wastes are less harmful to the environment than those of other space propellants. Its formulation also includes methanol, ammonia and water.

ECAPS says that the new fuel is more stable, more efficient and safer to handle than hydrazine. It allows for the reuse of propulsion system components designed to use hydrazine.



Test bench for IAE engines, in São José dos Campos, upstate São Paulo

Fuel containing ethanol is indicated principally for positioning of satellites in orbit

propellants and has the appeal of sustainability. Ethanol is a renewable fuel widely available in Brazil,” she says.

INPE’s effort to develop an ethanol-based space propellant began three years ago. Led by industrial chemist Ricardo Vieira, head of the LCP, the research team included PhD candidate Leandro José Maschio, from the Engineering School of Lorena, University of São Paulo (USP). Although it can be used in rockets, the new fuel is intended mainly for satellites. “Our propellant would be better for what are known as apogee engines, used to transfer a satellite into its orbit,” explains Vieira. After being launched into space, satellites need to position themselves in the correct orbit, and the displacement is performed by thrusters on the satellite itself.

STRATEGIC ADDITION

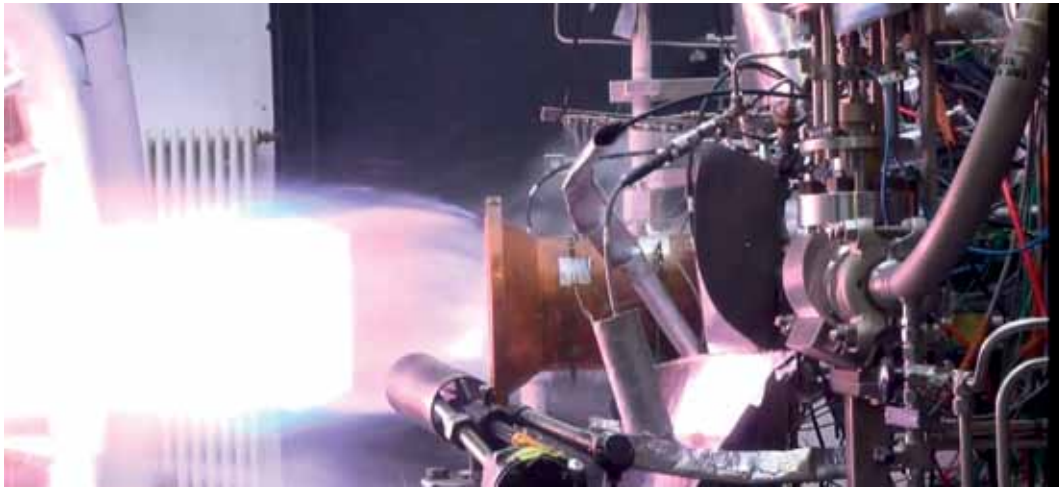
The new propellant, according to Vieira, has an efficiency close to that of traditional fuels. “The composition contains about 30% ethanol, 60% ethanolamine [an organic compound resulting from the reaction between ethylene oxide and ammonia] and 10% copper salts,” says the head of the LCP. “The addition of ethanol was purely strategic, since Brazil is a large alcohol producer. However, during development, we found that ethanol increased engine performance, reduced fuel ignition time and reduced fuel price.”

To make the engine work, the mixture of ethanol, ethanolamine, and copper salts reacts with hydrogen peroxide. “It acts like an oxidant by providing oxygen for the reaction, as oxygen does not exist in space. Hydrogen peroxide decomposes when it comes into contact with the fuel. The reaction is catalyzed by the copper and generates heat—around 900°C—which ignites the ethanol from the ethanolamine,” Vieira explains. Large volumes of gases are produced, and this gives the desired propulsion. Spontaneous combustion occurs when the chemical components come into contact. Mixing is controlled by software and, if possible, by ground-based technicians.

Another advantage is the low cost. INPE imports hydrazine for approximately R\$ 700/kilogram (kg) and nitrogen tetroxide for R\$1,300/kg. “We estimate that the ethanol- and ethanolamine-based fuel will cost approximately R\$ 35/kg and hydrogen peroxide will cost R\$ 15/kg. Since a satellite carries more than 100 kg of propellant, the savings is great in this aspect, but relatively small in relation to the final cost of the system,” emphasizes Vieira. “But if we take into account future use in rocket launcher stages, the savings could become quite significant.”

To demonstrate that the propellant is feasible and works, INPE designed and successfully tested a thruster employing the new fuel in its laboratory. According to Vieira, the next step would be to manufacture a larger engine and perform tests in a vacuum, simulating conditions in space. He says that the AEB has already shown interest in financing the manufacture and testing of an engine using ethanol-based fuel. “If we plan the project well and find the right partners, I believe the ethanol-ethanolamine engine could be ready in 10 years,” says Gurgel.

At IAE, the team in charge of designing an ethanol-fueled rocket engine achieved an important



Test of an L75 engine carried out in 2016 in the German Space Center, together with Brazilian researchers

milestone by conducting successful tests. The tests were carried out in late 2016 in the laboratories of the DLR Space Propulsion Institute, in Lampoldshausen, Germany, which is working with IAE on the project. The L75 engine employs liquid oxygen and better-quality ethanol than that sold for cars. Its name is a reference to the liquid fuel (L) and engine thrust of 75 kilonewtons (kN)—enough to lift a 7.5-metric-ton truck off the ground.

DOUBLE THE PERFORMANCE

The design of the L75 motor began at IAE in 2008, and five years later, DLR technicians and scientists also began working on the project. The tests carried out this year in Germany assessed two fuel injection heads based on different concepts, developed simultaneously by IAE and DLR researchers. The objective of the evaluations was to determine combustion performance parameters and define the best propulsion technology. The two heads differ in the way in which the fuel is sprayed into the combustion chamber and mixed with oxygen.

“In this first series of tests, the main objectives were achieved,” said German aerospace engineer Lysan Pfützenreuter, project manager at DLR. “We achieved 42 successful ignitions during a period of 20 days. We were able to closely analyze the behavior and stability of the system during ignition and startup in the thrust chamber, among other things.” Preliminary analyses of the results showed that the two heads had similar performances.

Cooperation between IAE and the German DLR dates back to 1960, when the Barreira do Inferno Launch Center (CLBI), in Rio Grande do Norte State, was used to launch rockets related to scientific experiments for the Max Planck Institute for Extraterrestrial Physics in Germany. Around the year 2000, the cooperation was

In the late 1960s, rockets from the Max Planck Institute were launched from the Barreira do Inferno Center

strengthened through an agreement to jointly develop a two-stage probe rocket, which was named VSB-30 and had its qualifying flight in 2004. More recently, in 2012, the Germans used a Brazilian suborbital rocket, the VS-40M, to carry the Shefex II (Sharp Edge Flight Experiment) into space. The goal of this cooperation was to develop key technologies, such as heat protection systems for spaceships with the ability to go into space and return to Earth, which requires withstanding the harsh conditions of re-entry into the atmosphere.

According to IAE, it will take approximately 10 years for the L75 engine to undergo its first qualifying flight, which is when all thruster parameters will be tested. The project was divided into four stages (feasibility study, preliminary design, detailed design and qualification) and is currently concluding the second stage. “The next step is to prepare the detailed design, which should take place from 2017 to 2021. Then, from 2022 to 2026, the L75 engine will enter the qualifying stage, and after that period it will undertake its first flights,” says Almeida. ■

Project

Study of hypergolic ignition of hydrogen peroxide and ethanol through a catalyst (No. 14/23149-2); Grant Mechanism Regular Research Grant; Principal Investigator Ricardo Vieira (INPE); Investment R\$156,558.58.

More resistant sugarcane fields

A variety of genetically modified sugarcane developed by a company from Piracicaba is approved for planting

PUBLISHED IN AUGUST 2017

Brazil is the world leader in sugarcane production, with 8.9 million hectares planted

Brazil is the world leader in sugarcane production, with 8.9 million hectares planted and an estimated harvest of 647 million metric tons this year. The main reason these numbers are not higher is the sugarcane borer, the larval phase of the moth *Diatraea saccharalis*, the most common pest on sugarcane plantations. The annual losses caused by this insect in Brazil average almost R\$5 billion plus the cost of control measures, with an average area of 521,000 hectares affected. In an attempt to resolve this problem, the Sugarcane Technology Center (CTC), a Brazilian company located in Piracicaba, São Paulo State, developed a ge-

netically modified sugarcane variety resistant to the pest. Named CTC 20 Bt, this variety was approved in June of this year by the Brazilian National Technical Biosafety Commission (CTNBio), which is the governing body responsible for assessing the biosafety of genetically modified organisms (GMOs) in Brazil.

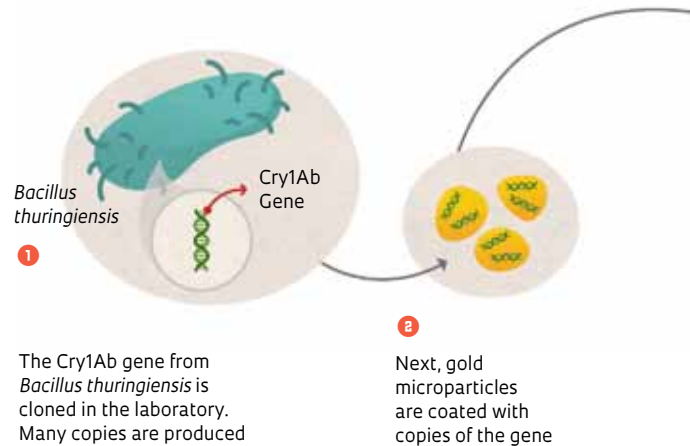
Antonio de Padua Rodrigues is the technical director of the Brazilian Sugarcane Industry Association (UNICA), the members of which are responsible for more than half of Brazil's sugarcane production. He explains that the development of the CTC genetically modified sugarcane reflects the technological advances of the Brazilian sugarcane industry. "With the definitive arrival of these genetically modified versions on the market, producers will have more profitable sugarcane plantations that will be more resistant to diseases and pests," UNICA declared in an official statement.

With the approval of CTNBio, the genetically modified sugarcane will be introduced gradually, and the planted areas will be monitored. The sugarcane will initially be sold only to selected producers mainly from the central-southern region of Brazil (to which this variety is better adapted), and these producers will

The genetic modification process

How Brazilian researchers created the CTC 20 Bt variety

SOURCE CTC

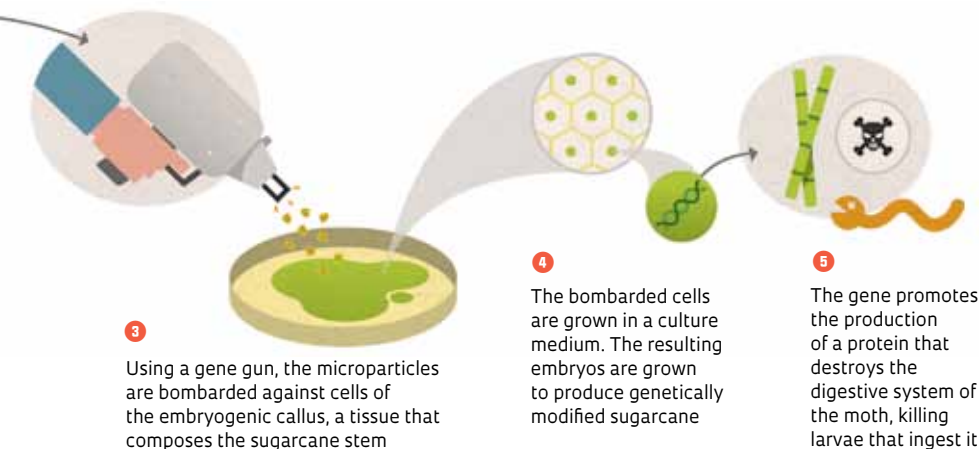


commit to following standards for control and reproduction without industrialization. For two to three years, all of the sugarcane produced will be used as a seedling. "We will also develop genetically modified varieties for other regions and different soil types," says agricultural engineer William Lee Burnquist, director of Genetic Improvement at the CTC.

The life cycle of the moth begins when eggs are laid on the leaves of the sugarcane plant. After they hatch, the larvae begin to eat the pulp of the culms (stems). The holes they make weaken the plant, which is then more easily blown over by the wind. This damage also leaves the plant more prone to attacks by fungi such as *Colletotrichum falcatum* and *Fusarium moniliforme*. These species cause red rot, a disease that re-



Annually, the sugarcane borer causes an average loss of almost R\$5 billion and compromises 521,000 hectares of sugarcane plantations in the country



3 Using a gene gun, the microparticles are bombarded against cells of the embryogenic callus, a tissue that composes the sugarcane stem

4 The bombarded cells are grown in a culture medium. The resulting embryos are grown to produce genetically modified sugarcane

5 The gene promotes the production of a protein that destroys the digestive system of the moth, killing larvae that ingest it

duces the purity of sugarcane juice and the quality of both the sugar and alcohol produced from the plant.

Genetically modified sugarcane was developed to address these problems. “We introduced the Cry1Ab gene from the soil bacterium *Bacillus thuringiensis* into the plant genome. This is the same bacterium used to develop genetically modified insect-resistant corn, soybeans, and cotton,” Burnquist explains. Cry1Ab is cloned in the laboratory using genetic engineering. Next, gold microparticles are coated with copies of the gene and introduced into the sugarcane genome, which then produces a protein toxic to the moth (see infographic above). The modified plant is reproduced in a nursery and then grown in the field. “Larvae are in contact with this toxin as soon as they are born,” says Burnquist. “When they hatch, they begin to feed on the plant. They ingest the protein and die before they can bore holes into the stem.”

Currently, producers fight the sugarcane borer with chemical insecticides and biological control—in this case, small wasps of the species *Cotesia flavipes* are released into fields to parasitize caterpillars (see Pesquisa FAPESP, issue No. 195).

Research at the center began in 1994, which later benefited from the professional training provided by the Sugarcane Genome Project between 1998 and 2004. Several groups from different universities and research institutions imple-

The new variety was considered to be safe for the environment, human health and animal health

mented this project, which was financed by FAPESP and the CTC. “There was a lot of professional training in sugarcane biotechnology at that time. Here at the CTC, many of the professionals were part of the Sugarcane Genome Project at Allelyx [the corporate spin-off of the Genome Project, later acquired by Monsanto] or took classes with those who participated,” says Burnquist.

At the end of 2015, the company filed a CTNBio application for commercial release. Several subcommittees within

CTNBio have analyzed the biosafety of the genetically modified plant. These committees consider the new variety to be safe for the environment, human health, animal health, and the plant itself. CTC studies have shown that the Cry1Ab gene is eliminated from sugarcane derivatives during the sugar and ethanol manufacturing process and does not cause damage to the soil.

The CTC has already asked authorities in the United States, Canada, and other countries to approve the sale of sugar produced from genetically modified sugarcane, although this approval is not likely to occur for another few years. Of the 150 nations to which Brazil exports this crop, approximately 40% currently have laws limiting or prohibiting sugar from genetically modified sugarcane.

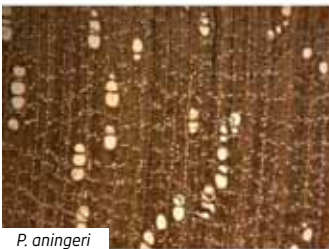
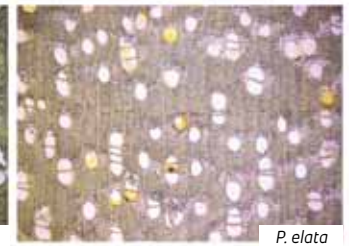
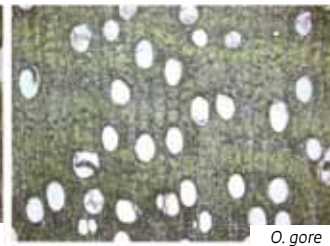
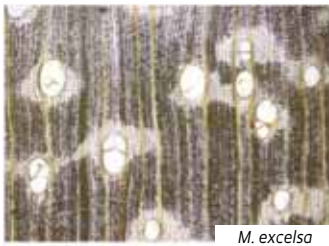
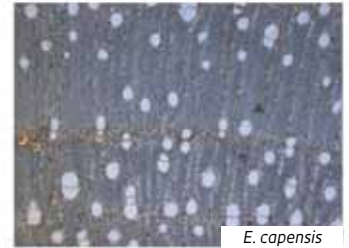
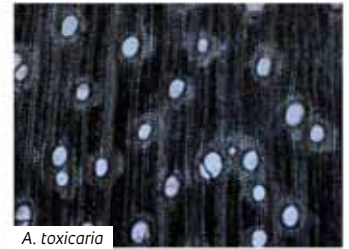
Another study to make sugarcane immune to pests is being performed at the Luiz de Queiroz College of Agriculture at the University of São Paulo (ESALQ-USP) in Piracicaba. There, since the 1990s, agricultural engineer Márcio de Castro Silva Filho has been dedicated to understanding how sugarcane reacts to insect attack (see Pesquisa FAPESP, issue No. 125).

A few years ago, this researcher discovered a sugarcane gene that exhibits antifungal properties. Known as sugarine, this gene stimulates the production of toxic substances that kill the fungi that cause red rot. “We found that genes that expressed proteins against *Diatraea saccharalis* when larvae attack the plant do so in a systemic way; in other words, all of the tissues in the plant produce these proteins,” explains Silva Filho. “In the case of sugarine, it is different: the gene is expressed only at the point where the moth larva has attacked.”

This discovery led the researcher to study the phenomenon. “We then found that the protein expressed by sugarine affects not the caterpillar but the fungi *C. falcatum* and *F. moniliforme*,” he recalls. “Recently, we discovered that sugarcane varieties with higher sugarine expression exhibit lower levels of fungal infestation. This discovery could aid in the development of more tolerant varieties.”

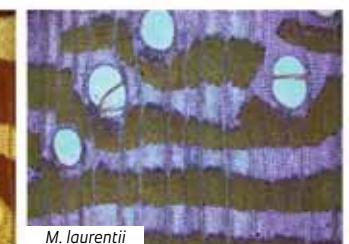
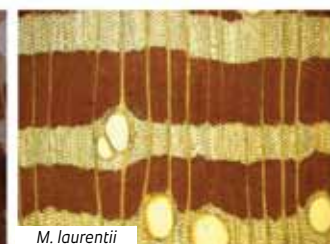
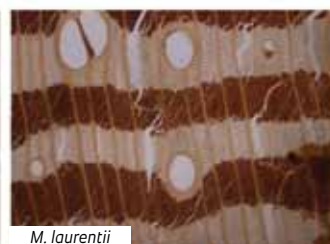
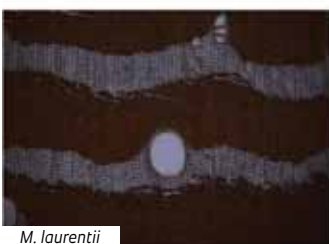
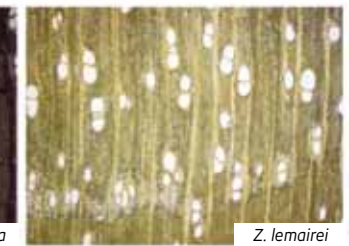
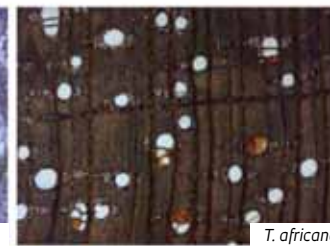
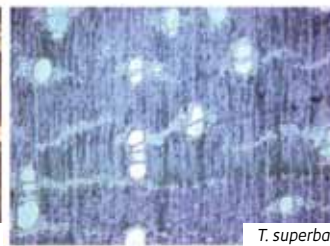
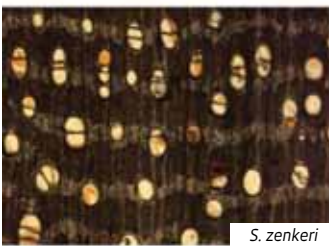
Annually, the sugarcane borer causes an average loss of almost R\$5 billion and compromises 521,000 hectares of sugarcane plantations in the country. ■

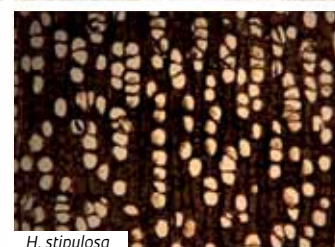
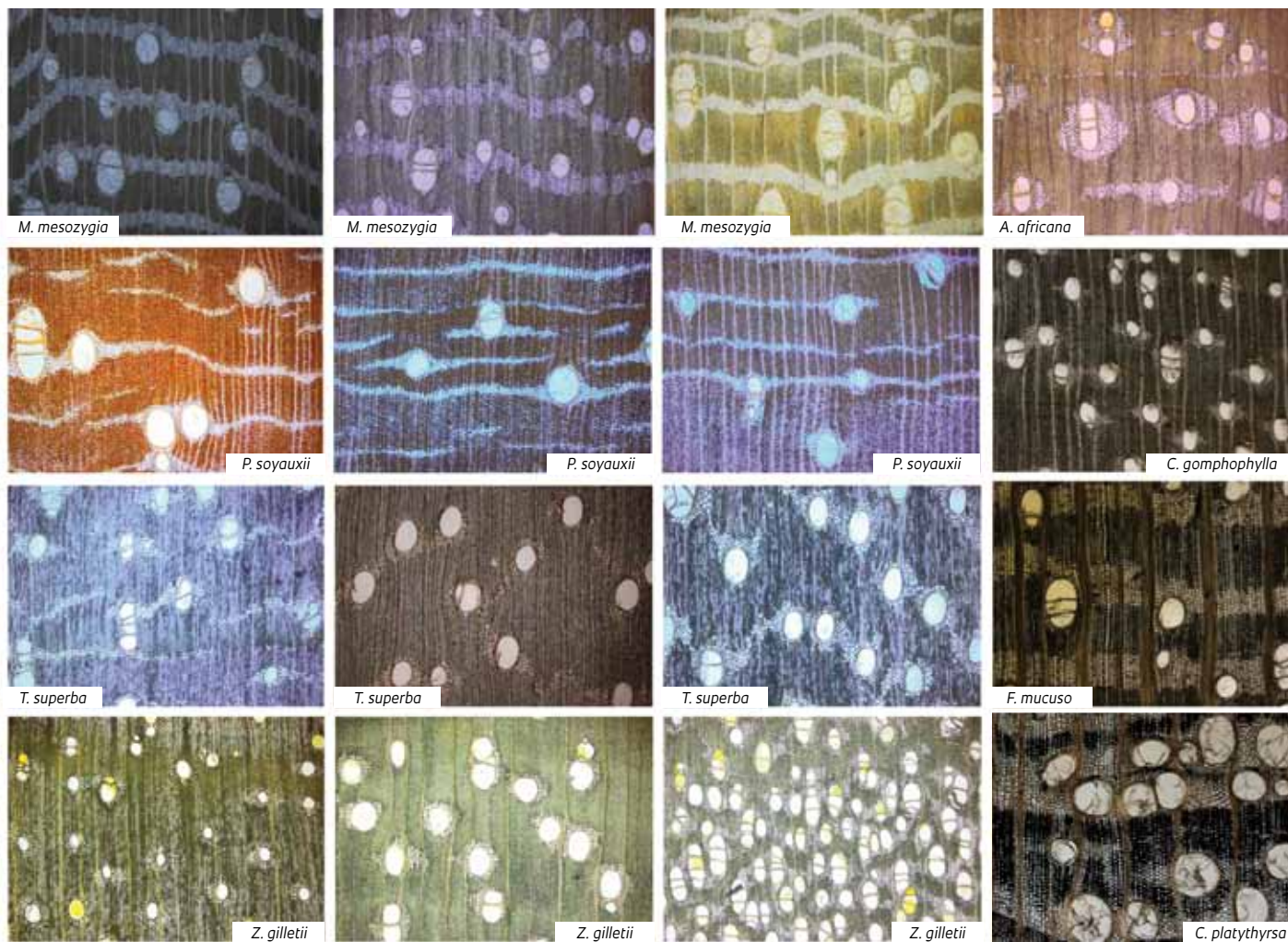
Wood identification



Computer vision systems identify the quality of wood boards and their tree species

PUBLISHED IN JULY 2017





Microscopic images show structural details of woods from different types of African trees

Two artificial vision systems that use images to identify and classify woods have recently been developed in São Paulo. One such system, called NeuroWood, was designed by researchers from São Paulo State University's (UNESP) Itapeva campus, and the Institute of Mathematical Sciences and Computation at the University of São Paulo (ICMC-USP) in São Carlos. It consists of a set of webcams, a computer and a software program that differentiates the wood into three categories: A (Excellent), B (Good) and C (Rejected). The other system, created at the USP Physics Institute in São Carlos (IFSC-USP), is a mathematical method that led to software that can determine the species of tree that the board came from. The two technologies are intended primarily for the wood and furniture industries.

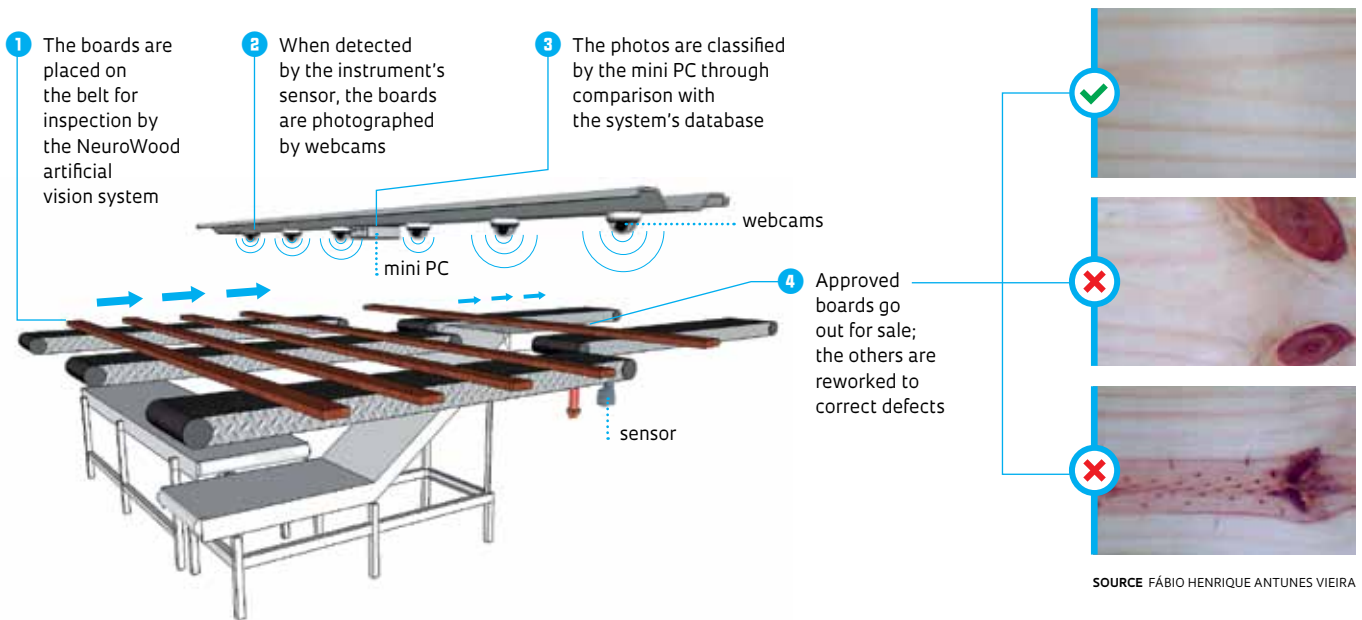
The wood industry usually uses technicians who classify board quality by visual inspection. It is a subjective process that relies on the quality of their training, and the percentage of correctly identified

wood is therefore not very high. Studies show that the level of accuracy hovers at approximately 65%.

In light of this scenario, mechanical engineer Carlos de Oliveira Affonso, a professor in the wood industry engineering program at UNESP/Itapeva; computer scientist André Luís Debasio Rossi, a professor in the production engineering program at UNESP/Itapeva; and civil engineer Fábio Henrique Antunes Vieira, a professor at the Capão Bonito School of Technology in São Paulo State designed an instrument to perform wood classification automatically. The NeuroWood project is receiving support from the Center for Mathematical Sciences Applied to Industry (CeMEAI), one of the Research, Innovation and Dissemination Centers (RIDCs) funded by FAPESP, headquartered at the ICMC. The system consists of a webcam, a monitor and a programmable logic controller (PLC)—a microprocessor that handles the interface between the computer and the actuators (electric motors or conveyor belts).

Eyes on wood

Learn how the instrument analyzes and classifies wood boards according to quality



The computer program that they developed uses machine learning techniques. “They are similar to the ones used by facial recognition systems, but simpler,” Affonso says. They are built using artificial neural networks, computer techniques that mimic the functioning of the human brain to learn from experience. “To do this, the computer is given a numerical pattern corresponding to a given class of objects,” he explains. “After a certain number of repetitions, these programs are able to identify which class the object belongs to, even if it was never presented as an example.”

In the case of NeuroWood, the system was “taught” to classify the wood boards according to their quality (A, B or C). The software was provided with data on levels of quality and board defects, such as knots and cracks. A database was then created from more than 600 photos of samples of all three qualities. The photos were processed to improve contrast and brightness and to highlight details, taking into account features such as texture and color.

The system was tested under actual production conditions at Sguario Indústria de Madeira, a company in Itapeva that is a partner on the project. There, it was subjected to the same levels of pol-

One of the programs was tested in a sawmill under actual conditions and yielded a high level of accuracy

lutant dispersion, vibration and variations in light levels as in a normal environment at a furniture or wood manufacturer. The cameras were installed along and above the sawmill’s classification conveyor belt. “The captured images are sent to the computer for processing and comparison with the ones in the database. Using this procedure, the software determines board quality as A, B or C,” Affonso explains.

According to Affonso, the results were satisfactory. “The system’s wood classification performance was similar to what

we observed in the lab,” he noted. “It is now analyzing 45 boards per minute—a task that would require six workers. The level of accuracy, 85%, was also higher than that of the specialized technicians.”

SPECIES IDENTIFICATION

The software developed at the Physics Institute in São Carlos also yielded good results, but that case involved the identification of tree species by their wood. Pieces from the Royal Museum for Central Africa in Tervuren, Belgium, were analyzed. They represented 77 different species of lumber trees that are typically sold in African countries. The work was carried out in partnership with Belgium’s Ghent University. “The success rate was 88% at the botanical species level, 89% at the genus level and 90% at the family level,” says computer scientist Odemir Martinez Bruno, a professor at IFSC-USP in São Carlos, who coordinated the project.

To perform the identification, the program is fed microimages of wood pieces. “Each species has a distinct composition of cellular structures that differentiates it from the others,” Bruno says. “The software analyzes the microscopic patterns formed by the wood’s cellular arrangements.”



Artificial vision systems could help with the inspection process in Brazil's wood industry

ALAN MARQUES / FOLHAPRESS

Bruno explains that this project is an offshoot of another project being conducted by his team, an ongoing, long-term study of plant biodiversity and identification and plant physiology using computers. In the case of the microimage identification software, he says that for now, the work is purely academic. “The article was published in a scientific journal in that field, and it could attract attention from companies that are interested in turning it into a product,” he conjectures.

According to Bruno, to date, there is no quality control or inspection system that can verify commercial wood species. “Our software can be used for quality control, product certification and inspection. It could be used by inspectors to ensure that a given shipment of wood was not sourced from a forest reserve, or from a species protected by law because it is native or in danger of extinction.”

INDUSTRIAL USE

NeuroWood, which was founded by UNESP's Affonso, was the subject of a patent filing at the Brazilian National Institute of Industrial Property (INPI) and is ready for use. The company that offered its production line for system testing could be one of the first to adopt it. Today, Sguario

produces between 15,000 and 20,000 wood boards per day and does not routinely classify boards according to quality. The pieces are evaluated only by their size. “It would be practically impossible to do a board-by-board visual inspection,” says Luiz José Sguario Neto, a partner in the sawmill. “With the UNESP system, it's possible to separate boards by quality and use differentiated pricing.”

That system is not entirely novel. There are other, similar systems on the global market that also use computer vision to classify wood. The problem is that they are costly, which hinders acquisition by small and medium-sized companies. “The cost of installing the equipment runs around R\$65,000, and imported systems are about R\$1.8 million,” Affonso says. “The difference is due to the fact that we are developing our own software.” To enable the system to be freely used with no need to purchase commercial packages, all the routines were written in open-access computer language. The use of cryptography makes it difficult to pirate the software.

Although the system is ready for use, Affonso has no plans to establish a company to make the software. “Our group's focus is to operate academically,” he says. System improvements, however,

will now continue, in partnership with com the University of Oulu in Finland. To that end, a contract has been signed between UNESP and that institution's Center for Machine Vision and Signal Analysis (CMVS) to promote student-faculty exchanges. “Like us, the Finnish group noticed that the main difficulty in building an automated image classification system lies in the computer learning phase. It requires a great deal of manual labor to build the database needed for the program to learn from the samples,” Affonso comments.

He has been doing postdoctoral research in Finland since February 2017 and will remain there until the end of 2018 to study ways to speed up the online learning process. “The idea is to look at the sample images, identify which ones add more information, and prioritize them during the learning process.”

Carlos Alberto Oliveira de Matos, who heads the wood industry engineering program at UNESP/Itapeva, believes Affonso's project is important because it involves undergraduate students and because it partners with lumber companies. “It has shown a high-level capacity on the part of the university's applied research for solving production-related problems,” he explains. “Brazil's lumber potential is unmatched around the world; it calls for specialized personnel and high-level research,” he points out. “These factors contribute urgently necessary added value to wood-based products.” ■

Projects

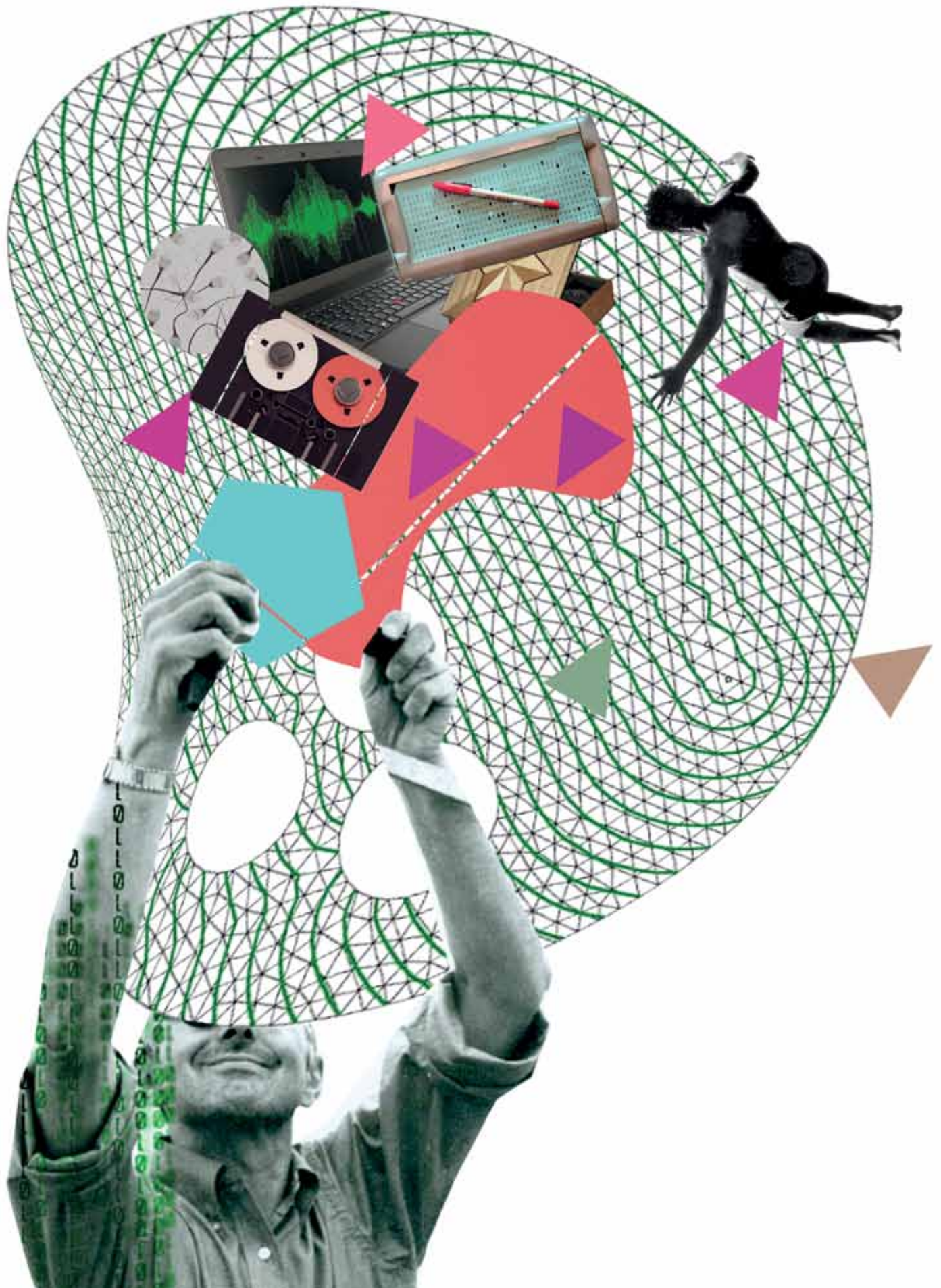
1. Artificial vision and pattern recognition applied to vegetal plasticity (No. 14/08026-1); **Grant Mechanism** Regular Research Grant; **Principal Investigator** Odemir Martinez Bruno (USP); **Investment** R\$174,860.82.
2. CeMEAI – Center for Mathematical Sciences Applied to Industry (No. 13/07375-0); **Grant Mechanism** Research, Innovation and Dissemination Centers (RIDC); **Principal Investigator** José Alberto Cuminato (ICMC-USP); **Investment** R\$27,982,568.59 (for all projects during a five-year period).
3. Adaptive visual inspection methodologies for low cost high performance systems (No. 16/23410-8); **Grant Mechanism** Scholarships Abroad; **Principal Investigator** Carlos de Oliveira Affonso (Unesp); **Investment** R\$129,810.62.


Scientific articles

- AFFONSO, C. *et al.* Deep learning for biological image classification. **Expert Systems with Applications**. May 17, 2017.
- SILVA, N. R. *et al.* Automated classification of wood transverse cross-section micro-imagery from 77 commercial Central-African timber species. **Annals of Forest Science**. June 2017.

HUMANITIES

COMPUTER SCIENCE ▾





The reality emerging from an **avalanche of data**

Digital humanities are spreading through a variety of disciplines, influencing the training of researchers and driving public policy

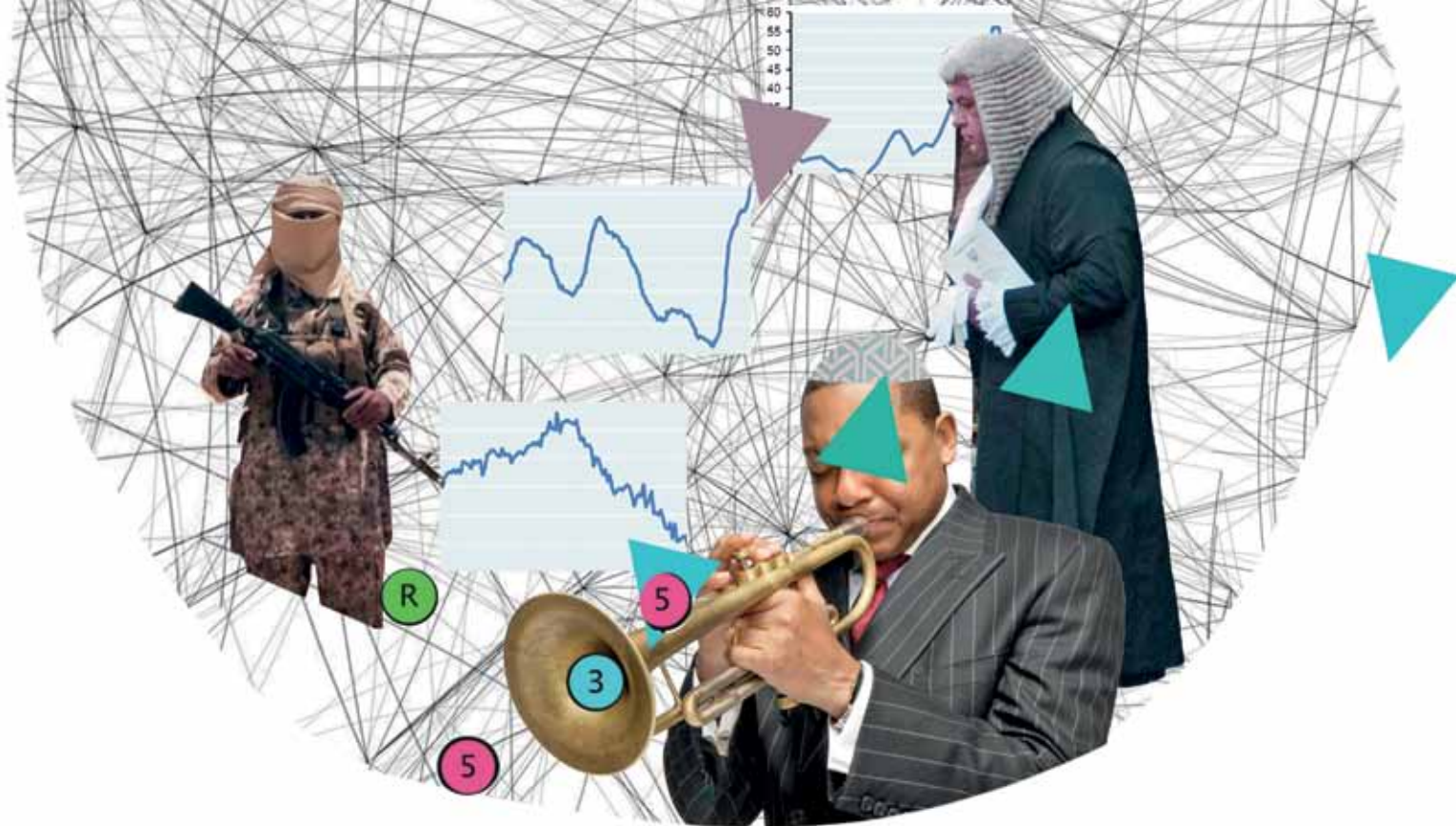
Fabício Marques

PUBLISHED IN MAY 2017

Computers are tools used in the work of researchers in all fields of knowledge, but in the communities of the humanities and social sciences, the digitization of artistic and historical collections and the input of economic and social information into giant databases have opened up new frontiers for observing phenomena and analyzing trends. This expansion has rather naturally developed into a closer relationship with computer scientists, whose Big Data research studies have multiplied the ways to organize and analyze information, giving rise to an interdisciplinary field known as the digital humanities. “The term was coined to define research that uses computational technology to study the humanities, but it also refers to the research that uses the humanities to study digital technology and its influence on culture and society,” explained Brett Bobley, director of the Office of Digital Humanities at the National Endowment for the Humanities (NEH),

a U.S. government funding agency. “This is not a new field,” said Bobley, “but rather a range of activities that can include the use of aerial photographs by archeologists to scan sites, the development of data analysis techniques that help linguists study old newspapers, and the study of the ethics of the technology by philosophers, to give just a few examples.”

One of the NEH-funded projects in digital humanities recovered the field diaries of British explorer David Livingstone (1813-1873). Historical accounts of his 1871 voyage to Central Africa were written on old newspapers because no paper was available. Over time, the ink faded, and the writings in which Livingstone recorded his impressions about the dynamics of the slave trade, among other observations, were rendered illegible. Between 2013 and 2017, a group of humanities and computer science researchers from the United States and the United Kingdom were able to recover the writings by using spectral imaging



photographic techniques that permitted retrieval of information invisible to the human eye.

Another example was the collaboration between historians from several parts of the world in organizing records about nearly 36,000 slave ship voyages that took place between 1514 and 1866, carrying more than 12 million slaves from Africa. The effort, begun in the 1990s by American historian David Eltis at Emory University, resulted in the Trans-Atlantic Slave Trade Database, available online since 2007 at slavevoyages.org. The analysis of the data, assembling records in several languages and encompassing the activities of the ports through which the vessels passed, has offered the historians new insights on how Africans experienced and resisted deportation and enslavement and revealed new transatlantic connections in the slave trade.


An initial compilation was released as a CD-Rom in 1999, but the collaborative effort to obtain data about the voyages put together a more complete picture of the slave trade. During its initial phase, it is estimated that Brazil took in nearly 3.6 million slaves, but documents showed that this contingent was closer to 5 million—for a total of 10.7 million Africans deported to the Americas. “The initiative had a considerable impact on the research about slavery,” said Manolo Florentino, a professor at the Federal University of Rio de Janeiro (UFRJ) in charge of the Brazilian arm of the project. Chief among them was the fact that it replaced estimates with solid data obtained from primary sources. Another impact was that it dis-

Database of slave trafficking demonstrated Brazil’s prominence in the slave trade

played Brazil’s prominence in the slave trade. “A large number of the documents obtained through the project are written in Portuguese, a sort of lingua franca of the slave trade,” said Florentino, who in recent years has embarked on efforts to translate the entire site into Portuguese. Florentino said that the collection of data on the deportation and enslavement of the Africans now provides information for a less-explored line of research involving the paths the slaves took inside Brazil after they arrived in the ports.

A VARIETY OF PROJECTS

The results of a recent international call for proposals has demonstrated the diversity of the digital humanities. One hundred and eight proposals by interdisciplinary teams from 11 countries were submitted during the fourth edition of what is known as the “Digging into Data Challenge,” and 14 were approved. The initiative is part of the Trans-Atlantic Platform (T-AP), a collaboration in the humanities and social sciences that



is bringing together 16 funding agencies from Europe and the Americas, including FAPESP. “We saw a noticeable increase in the number of countries taking part, which in previous calls for proposals had numbered only four. The surge in new collaborations is making a big difference,” said Brett Bobley, who devised the idea for the Digging into Data program in 2008. Approved projects encompass disciplines, such as musicology, linguistics, history, political science and economics, and they will receive investments totaling \$9.2 million, equivalent to R\$29 million. One of the proposed projects involves researchers from the United States, Germany and The Netherlands and will focus on three databases that make up the written and oral records of folklore from several corners of Europe. The goal is to identify patterns that reappear over time in different places to show which beliefs were common in the past based on the stories told and the spreading of legends and tales of supernatural occurrences.

Another example, led by economists and computer scientists from the United States, Canada and The Netherlands, plans to cross-reference information about price variations of products sold on the Internet all over the world, continuously collected by the Billion Prices project at the Massachusetts Institute of Technology (MIT), with economic data that can be used to produce research studies on inflation, purchasing power, and standards of living in several countries. There is also an initiative to analyze 70 years of press coverage of terrorist attacks in a search for patterns regarding what constitutes a responsible approach to the problem. Another project will investigate the melodic structures of jazz recordings in an attempt to connect them to the development of the historical and social context in which the songs emerged.

To select the 14 included projects, more than 200 experts evaluated the 108 proposals. “The variety of issues covered shows that there is a huge potential to be developed in the field of digital humanities in Brazil,” said Claudia Bauzer Medeiros, a professor at the Institute of Computing at the University of Campinas (UNICAMP) and FAPESP representative on the T-AP. Medeiros took part in the entire process, from drafting the call for proposals to selecting the projects. “The field is under-explored in Brazil because there is still so little collaboration among researchers from the humanities and social sciences and computer science. They’re gradually realizing that this interaction is possible. Researchers in the humanities and social sciences don’t have to understand computing to work well in this field, but they do have to collaborate with experts on

London in the fight against crime

Tools explore data on 197,000 trials

Records on 197,000 trials conducted between 1674 and 1913 by London's Central Criminal Court, commonly referred to as Old Bailey, which is the name of the street on which the court is located, were made available for consultation on the Internet back in 2003 on oldbaileyonline.org. The challenge posed by the task of identifying phenomena and trends buried in a volume of information approaching 127 million words mobilized researchers from the United Kingdom and the United States to develop ways to tap textual data that were much more sophisticated than performing a search of the repository.

The project, known as “Data Mining with Criminal Intent,” funded in 2009 under the initial call for proposals for the Digging into Data project, scoured the records of Old Bailey with the help of a combination of digital tools. One of them was Zotero, which allowed for the collection and organization of information, and the other was a portal called TAPoR that helped users analyze writings through a variety of software. The strategy has led to some interesting results.

It was possible to see, for example, that the word “poison” was much more commonly associated with “coffee” than with “food,” indicating how Londoners were murdered by poisoning.

By the same token, one notes that punishments for bigamists became less severe throughout the 19th century. According to Stephen Ramsay, a professor of English at the University of Nebraska-Lincoln, one of the leaders of the initiative, the project’s contribution was not limited to obtaining previously unnoticed historical evidence.

“The stories of Old Bailey express the darker motivations behind the human condition, such as revenge, dishonor and loss, which is the raw material of the humanities,” he said, according to *The Chronicle of Higher Education*.

aspects of computing,” said the researcher who is also the coordinator of the FAPESP Research Program on eScience.

Brazilians are participating in one of the projects selected under the Digging into Data Challenge. It involves a collaboration among researchers from France, Argentina and Brazil studying how opinions spread in society and how the process has changed as a result of advances in information technology. The study will analyze two databases to map the establishment of networks of relationships among groups of individuals; such connections will be represented in visual structures (graphs). In one collection by the *New York Times* newspaper, the objective will be to analyze reports about Brazil published over the course of 70 years to map the relationships between groups of individuals and entities mentioned in the pieces that mentioned Brazil. “The plan is to understand where they came from and how the ideas and opinions reproduced in the texts were related, especially those regarding political and economic topics, and how this has changed over time. We also want to determine the possible influence that news by foreign correspondents published in that newspaper had on the formation of public opinion in Brazil,” explained Maria Eunice Quilici Gonzalez, researcher and head of the Brazilian group that



is taking part in the project and a professor in the Department of Philosophy of the School of Philosophy and Sciences at São Paulo State University (UNESP), Marília campus.

The second database is a collection of Twitter postings on electoral processes. The idea is to show how opinions form and grow stronger in the virtual environment. “We would like to analyze the dynamics of how opinions spread through social media. The more extensive the relationships, the tighter are the network connections represented in the graphs. The trend

How São Paulo became urbanized

Platform will assemble geo-referenced data about the transformation of São Paulo’s capital city from 1870 to 1940

São Paulo urbanized at a faster rate than other cities, growing from only 30,000 inhabitants in 1870 to one million in 1940. The study of the city’s transformations during this period will be supported by a platform of geo-referenced information, supplied by numerous sources, such as theses, reports and maps. Any researcher who has data and can relate them to an address in the São Paulo capital is invited to include them in the Pauliceia 2.0 platform, whose design was opened to suggestions from potential users on April 4, 2017.

The project, which brings together researchers from the Federal University of São Paulo (UNIFESP), the National Institute for Space

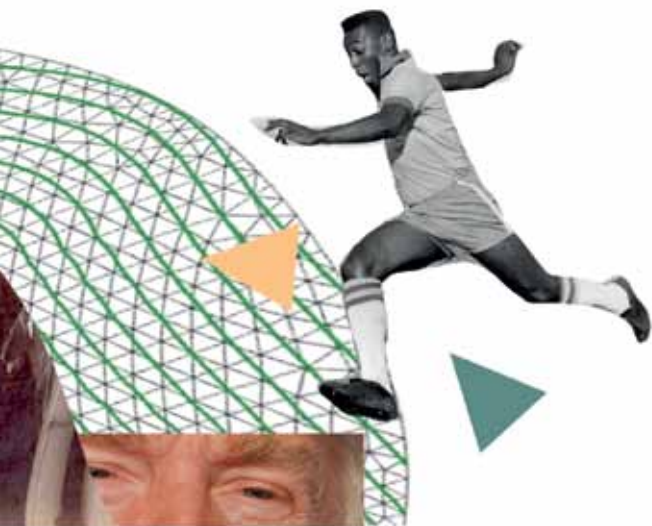
Research (INPE), the São Paulo State Public Archives and Emory University, is funded by the FAPESP research program in eScience. “Anyone who has studied São Paulo’s hotels could add information about them to the addresses. Anyone who has studied crimes committed in the city can do the same for that data. Any information that can be referenced in the space can be added to the platform,” said historian Luis Ferla, the UNIFESP professor who coordinated the project.

There is one project team that is dedicated to developing a database of the numbering on buildings of that time to ensure that data localization is reliable. “It is such complex work that it is first being tested in a pilot



area, in downtown São Paulo,” Ferla explained. A preliminary version of the platform will be available for testing in July 2018. “Anyone who wants to study this period will find a lot of material on the platform to use in their analyses. The project seeks to curate knowledge about the city’s urbanization.” More information is available at unifesp.br/himaco.

The city in the 1940s, when it reached its first million inhabitants



is for them to take center stage and inhibit the growth of other connections, thus showing the pathway to how opinions are formed,” Gonzalez reported. One of the group’s interests lies in studying the formation of politically polarizing environments on social media. “Groups that once were isolated are now able to reinforce their opinions and gain followers, feeding off of communications on social media,” Gomez said. “This happened recently, for example, with groups for or against impeachment in Brazil.” In addition to specific objectives, the project has more general ambitions, including assessing possibilities for creating models to study social practices and investigate the potential ethical consequences of using Big Data analysis on processes of social self-organization, which are those that emerge from spontaneous interactions among various social actors—leaderless and without interference from an organized center.

The project will be carried out in partnership with researchers from the universities of Cergy-Pontoise in France and Buenos Aires in Argentina. The team is critical of the idea that it is possible to shape behaviors or guide the formation of opinions by manipulating trends obtained through analysis of Big Data alone. “It would be an exaggeration to say that Donald Trump was elected president and that the British voted to leave the European Union solely because the respective campaigns hired the political marketing firm Cambridge Analytics to utilize data and social media tools to manipulate voters’ wishes and fears,” Gonzalez said. “The study of Big Data can identify trends, but it is far from capable of explaining human nature. Its use will only be efficient if it is accompanied by the study of the attitudes of certain groups, which in the case of the United States and the United Kingdom were related to the preponderance of nationalism and an aversion to multiculturalism.”

With an undergraduate degree in physics, a master’s degree in philosophy and a PhD in linguistics and cognitive science, Gonzalez will also contribute to the project, with the support of a team of Brazilian researchers, by providing ideas concerning the ethics involving individuals’ actions on social media. “The concept of privacy, for example, is changing. Some of the notions of privacy held by my generation do not apply to people on social media who systematically expose their personal details. There is also the issue of individuals who create false profiles, altering their personal characteristics, socioeconomic status and even their gender in an effort to virtually interact with others,” she said. In her view, if at home, many people have to maintain an identity they do not like, so they can live out their fantasies on social media without any apparent family pressures. “Their identity is fictitious, but the interaction that it provides can to some extent be real. They are able to use it to create a relationship with virtual partners, which in the past was not possible.” To address situations such as this, the Brazilian group will think about how Big Data analysis can help in the understanding of new patterns of behavior and the dynamics of formulating public opinion.

TOPICS AND ADVANCES

The next scheduled edition of the Digital Humanities conference in August 2017, which will bring nearly 1,000 researchers from several countries together in Montreal, Canada, gives us some idea of the scope of the topics and technological advances that have established bridges between computer scientists and professionals in the humanities and social sciences. Workshops will address topics, such as research applications in the humanities for computer vision tools, a concept used mainly in robotics through which artificial systems are able to extract information about images, simulating the functioning of the human vision system. They may also raise questions about ethical and legal problems related to the use of digitized data that could expose an individual’s privacy. Honored at the conference in Montreal will be those responsible for the Text Encoding Initiative (TEI) project, a consortium that has developed and maintained a standard for the representation of texts in digital format since the 1980s, making them machine readable, and driving studies in the human sciences, especially in linguistics. “In the last 15 years, we’ve had a qualitative change in the volume of textual data available, which has radically changed the possibilities of research,” said Karina van Dalen-Oskam, chair of the Steering Committee of the Alliance of Digital Humanities Organizations (ADHO), the entity that organizes the conference.

A historical corpus of the Portuguese language

Database containing 3.3 million words assembles annotations on writings from various eras

A collaboration with computer scientists has occurred more naturally in some fields of the humanities than in others. One example involves studies about changes in the use of language. Charlotte Galves, a professor at the Institute of Language Studies of the University of Campinas (IEL-UNICAMP), often said that she became devoted to the digital humanities long before she knew there was such a thing. In 1998, she began to compile 16th- to 19th-century writings to put together a historical corpus of the Portuguese language, a database of texts with morpho-syntactic annotations of words and sentences that had already served as a basis for a series of studies about the history of the Portuguese language in Portugal and Brazil. “It is now possible to observe how the language has changed over the centuries, particularly in Brazil, which has increasingly distanced itself from European Portuguese as a result of its contact with other languages, despite being influenced by it again during the second half of the 19th century,” said Galves.

The database has continued to grow and now contains 3.3 million words from 76 original documents. Named Corpus Tycho Brahe, in reference to the 16th-century Danish astronomer who documented the movement of the planets, the collection used its first word-labeling tools developed by computer scientist Marcelo Finger, a professor at the Institute of Mathematics and Statistics of the University of São Paulo (IME-USP). The database



Writings by Father Antônio Vieira (1608-1697) are part of the collection

grew slowly; corrections to the automatic notations were made by Galves herself, with the help of postdoctoral researchers and students she advised. “I learned a lot about Big Data, but I couldn’t do without the help of computer scientists,” she said. The next step is to make the database fully accessible on the Internet. It is possible to download the collection at: www.tycho.iel.unicamp.br/corpus, but it is not currently possible to search online.

The same model of historical Portuguese is now being used by Galves and Filomena Sandalo, also a professor at UNICAMP, for the study of an indigenous language, *Kadiwéu*, spoken by an ethnic group in the Brazilian state of Mato Grosso. Oral accounts by indigenous people were collected and are being converted into annotated texts. “The idea is to use the same platform to create the corpora for other languages, using the same tools,” Galves explained.

A professor of computational literary studies at the University of Amsterdam in The Netherlands, van Dalen-Oskam points to the progress that new approaches have made in researching literature, such as the concept of remote scanning, which analyzes large volumes of data related not only to the work being studied but also to the entire historical context in which it was produced, or to the field of stylometry that enables attribution of authorship to works of doubtful authenticity. “These approaches allow us to learn more about the development of literary genres and even about factors that make a particular text a best seller or not,” she said.

The growth of this interdisciplinary field is accompanied by criticism that the digital humanities have generated more headlines than solid advances in knowledge and that they compete with traditional humanities in terms of the allocation of research funding. In an article published in *The New York Times* in 2015, Armand Marie Leroi, a professor of evolutionary biology at Imperial College London, called into doubt digital humanities’ capacity to produce innovative analyses of literature. He said that converting art into data does make it possible to look for new meanings in a work through new algorithms. “But it would have to create a very smart algorithm capable of flagging irony in the work of Jane Austen,” he wrote. “The truth we talk about in art criticism is not the same as scientific truth.”

Researchers in this field respond with the argument that the digital humanities offer only an extension of traditional methods and skills and are not intended to replace them. *Digital Humanities* (MIT Press, 2012) states in its first chapter that the digital humanities “do not obliterate the ideas of the past, but rather supplement the commitment by the humanities to academic interpretation, informed research, organized argument and dialogue between the communities that practice it.”

Political scientist Eduardo Marques, a professor at the University of São Paulo School of Philosophy, Literature and Human Sciences (FFLCH-USP), pointed out that the approaches used by computer science and human and social sciences within the digital humanities come from different sources. “There was a meeting of two movements. One came from the hard sciences, with the development of data mining tools that enabled the production of information about the social world and the generation of new empirical fields. The human sciences, however, made use of existing statistical tools to study social phenomena,” he explained. Since the rationales are different, it is difficult to bring them together, Marques noted. “While the computer scientists



Courses and disciplines on quantitative and ethical analysis of the use of data are gaining ground

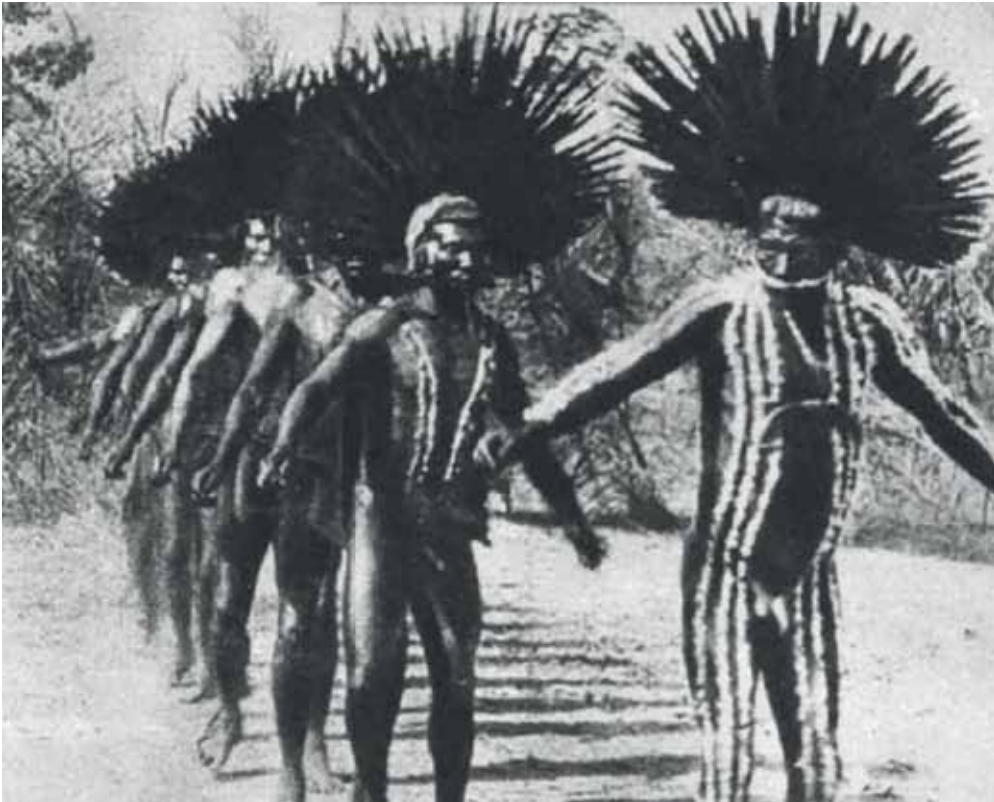
are looking for patterns in large volumes of data in order to raise research questions, the social scientists are working from theoretical assumptions and are using digital tools to test their validity,” he said. “There is a lot of dialogue, but it is hard to bring together different ways of approaching the issues.”

This dialogue has influenced the training of researchers. In the humanities and social sciences, courses and disciplines in quantitative methods and analysis are gaining ground. “This is good news because the social sciences have always had a huge weakness in this field in Brazil, which also extends to qualitative analysis and studies with small samples,” Marques explained, referring to initiatives, such as the Summer School in Concepts, Methods and Techniques in Political Science and International Relations offered by the International Political Science Association (IPSA), the Department of Political Science at FFLCH-USP and the Institute of International Relations at USP. Also growing in importance are disciplines on the ethical use of data. “It is an emerging issue and does not just look at how to prevent the dissemination of confidential patient data or sensitive public safety information,”

added Claudia Bauzer Medeiros. There is a risk of producing biased analyses because many computer programs “learn” as the data are processed. Software is being developed to identify long-term patterns and incorporate them into their analytical capacity. “There have been situations in which the learning inadvertently reproduced biases,” she said. “In the United States, it was discovered that a program used experimentally by judges in some cities to expedite rulings dealt more stringently with blacks and Latinos because it used as a lesson data from previous rulings.”

The development of computational tools that help analyze large volumes of data about health, demographics and violence is used in studies of social processes that are then applied in public policies. “Socioeconomic and demographic data analyses are often used in urban planning strategies. Digitization of data on migratory waves feeds studies that help us understand future trends in immigration,” said the IC-UNICAMP researcher.

An example of the growing involvement of the social sciences in Big Data in Brazil can be seen at the Center for Metropolitan Studies (CEM), one of the Research, Innovation and Dissemination Centers (RIDCs) funded by FAPESP. One focus of the center is to produce and disseminate geo-referenced data on Brazilian cities. Public agencies generated data that were not made available, and the information was appropriated by companies, which charged to provide them. The CEM purchased several databases and digitized others, making them available on its website (fflch.usp.br/centrodametropole). At first, the collections were not large enough to be associated with the notion of Big Data. This changed a few years ago when the center developed a database tailored toward a large research effort on the study of patterns of inequality in the last 60 years. Significant work was required to provide consistency to questionnaires and correct the gaps in a 1960 Census sample, whose punch cards had been lost, and to reorganize the information from five later censuses to generate comparable data. “This generated a multi-terabyte database of information, at a volume much larger than what is traditionally seen in Brazil’s social sciences,” said Eduardo Marques, who was CEM director from 2004 to 2009. The effort led to the book entitled *Trajetórias das desigualdades – Como o Brasil mudou nos últimos 50 anos* (Editora UNESP, 2015) [Paths of Inequality in Brazil: A Half-Century of Change], edited by current CEM Director, Marta Arretche, containing chapters written by experts on topics such as education and income, demographics, labor markets and political participation. Each chapter required a specific processing of data. ■



The Bororo on screen

Researchers suggest that a film made by the Rondon Commission in 1916 may have been the first ethnographic documentary

Christina Queiroz

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Scenes from *Rituais e festas Bororo*: dancing (left), fishing (center), and water being poured over a woman's body during a funeral ceremony

A team of anthropologists from Brazil and the United Kingdom has gathered enough evidence to suggest that the movie *Rituais e festas Bororo* [Rituals and festivals of the Bororo], filmed in 1916 by Major Luiz Thomaz Reis (1879-1940) at the request of Field Marshal Cândido Mariano da Silva Rondon, may be the first ethnographic documentary in history, even predating the existence of the term. *Nanook of the North*, produced in 1922 by U.S. filmmaker Robert Flaherty (1884-1951), had previously been considered the pioneer in this interdisciplinary tradition in which anthropology meets cinema.

Rituais e festas Bororo was completed in 1917 and premiered in Brazil that same year. Some scenes were exhibited at an event held at New York's Carnegie Hall in 1918, while Reis was on a visit to the United States. French anthropologists had the opportunity to view the documentary in the 1990s, but few in the United Kingdom saw it. In the early 1990s, a process that permitted a reassessment of the film's importance began, and it was only then that it began acquiring its status as an ethnographic groundbreaker.

Anthropologist Patrícia Monte-Mór, a professor in the Department of Anthropology at Rio de Janeiro State University (UERJ) and curator of the International Ethnographic

Film Festival, says that the starting point for this process was the work of French anthropologist Pierre Jordan, who published the book *Cinéma – Premier contact, premier regard* [Cinema: first contact, first point of view] in 1992, in which he charted the first film records in history across the continents. Jordan, who used an image from Reis's movie on the cover of his book, took up the argument that the film was unprecedented in the world of ethnographic documentaries. In 1993, *Rituais e festas Bororo* was screened at the first International Ethnographic Film Festival in Rio de Janeiro, where it drew the interest of anthropologists, documentary filmmakers, and scholars of cinema. "But the film wasn't in circulation yet and belonged to the Museum of the Indian collection. We showed a VHS copy of it at the festival," recalls Monte-Mór.

In the late 1990s and early 2000s, Fernando de Tacca, an anthropologist who is currently a professor at the Institute of Arts of the University of Campinas (IA-Unicamp), and Denise Portugal Lasmar, an expert in the preservation and organization of documentary collections and formerly the head of the audiovisual department at the Museum of the Indian, analyzed the imagery captured by the Rondon Commission and called attention to the innovations introduced by Reis's documentary. In his book *Cinéma et anthropology* [Cinema and anthropology] (Nathan, 2000), French anthropologist and filmmaker Marc Piault, who is affiliated with the School for Advanced Studies in the Social Sciences (EHESS), used research conducted in Brazil to analyze Reis's work; he also considered the film to be the world's first ethnographic documentary.

In 2014, British anthropologist Paul Henley, director of the Granada Center for Visual Anthropology at the University of Manchester in the United Kingdom, was awarded a research fellowship by the Leverhulme Trust, a private foundation based in London, to carry out a project exploring early ethnographic documentaries, particularly those from Brazil and France. Henley, who is an expert in ethnographic topics related to the Amazon and who trained in cinema, studied Reis's filmography at the archives of the Museum of the Indian, the Brazilian Cinematheque, and the National History Museum. He worked with two other anthropologists while in Brazil. One, Sylvia Caiuby Novaes, a professor with the Department of Anthropology in the School of Philosophy, Literature and Human Sciences at the University of São Paulo (FFLCH-USP), has been conducting research on the Bororo ethnic group for more than 30 years and spent time as a postdoctoral fellow under Henley's supervision in 1995. The other, Edgar Teodoro da Cunha, is now a professor in the Department of Anthropology, Politics,



Luiz Thomaz Reis with a 35-mm Debie camera in 1932; the army officer made a number of documentaries

and Philosophy at the Araraquara campus of São Paulo State University (Unesp). He was Novaes's advisee during his doctoral studies, which were focused on the Bororo and visual archives. The trio launched investigations in the field of visual anthropology, addressing the filmography of the Bororo ethnic group in particular, and authored an article on Reis's film, which was published in the journal *Visual Anthropology* in 2017.

The 30-minute-long film is divided into three parts depicting various activities related to the funeral ritual

LUMIÈRE BROTHERS

Reis, a military officer, established the Rondon Commission's Film-making and Photography Division in 1912. In 1914, he traveled to France, where he purchased cameras from Auguste and Louis Lumière, the brothers who invented the early motion-picture projector known as the cinematograph. Field Marshal Rondon assigned him to film the approximately 350 Bororo Indians who lived in a village on the banks of the São Lourenço River, 100 kilometers from Cuiabá, in Mato Grosso. The Rondon Com-

mission was a Brazilian government agency established in 1907 to construct a telegraph communication network linking the largest cities in northwestern Brazil. Botanists, zoologists, and other scientists took part in Rondon's expeditions, studying the fauna and flora along the routes, conducting ethnographic research of the material culture of indigenous groups, and recording anthropometric measurements of these peoples.

The documentary, filmed between July and October 1916, shows a woman's funeral ceremony. "Rondon, who had Bororo roots, knew that the



Reis, Rondon (middle) and an Indian of the Paresi ethnic group circa 1912

Indians were dying because of the epidemics and was well aware of how important funeral rites were in the culture of this ethnic group. He had watched and even participated in some,” says Novaes. The 30-minute-long film is divided into three parts that depict various activities related to the ritual, including a fishing expedition, a simulated jaguar hunt, and dances performed by Indians wearing traditional dress. It ends with a sequence that shows the body of the deceased woman wrapped in a mat and then buried in a shallow grave.

In his research on the film, Fernando de Tacca analyzed diaries and documents that indicate that Reis changed the order of the scenes to make the ritual more palatable to the public. Bororo funeral rites are lengthy. Shortly after death, the body is placed in a temporary grave in the middle of the village, where it is watered daily to speed up putrefaction. After the body decomposes, the bones are cleaned, adorned, and placed in a large funeral basket. After remaining in the village for approximately a week, the basket is carried to a lagoon, where it is submerged in the water. The entire process can last one to three months.

During this period, a number of rites are celebrated to honor the dead. Reis was unable to film some aspects of the ritual and cut some scenes, “reorganizing the filmed material,” in Cunha’s words. “The funeral ceremony still takes place the same way today, and it’s vital to the Bororo, since it also symbolizes the re-creation of their society,” says Novaes, who has witnessed more than 40 funerals.

Novaes contends that the film can be called an ethnographic documentary because it was shot over a period of 10 weeks, giving the director time to experience the Bororo culture personally and thus the ability to portray it later in his film, which underwent a process of cutting and editing. “An ethnographic documentary is a film whose making is based on extended interactions between filmmakers and native peoples and that tries to capture the viewpoint of those who are filmed. Today, this work also involves the active participation of the people portrayed, whether during the script phase, the recording of images and sound, or editing,” explains Novaes. According to the researcher, Reis’s film also has a narrative structure, unlike travel films of the era—such as those by Silvino Simões Santos Silva or Edgar Roquette-Pinto—where the directors arranged images according to the progress of their journeys and did not concern themselves with recording isolated events. “In *Rituais e festas Bororo*, Reis makes no reference to the journey behind the film but centers the narrative on the funeral ceremony,” Novaes says by way of comparison.

Other important features that distinguish Reis’s film from travel films of the same era are its documentary approach and well-developed narrative form. “Additionally, there is his commitment to a visual description of the Bororo culture aimed at a broader public, which would make it possible to link the film to a tradition that later came to be called ethnographic film,” explains Cunha. In the opinion of Henley, another difference is that travel films made during the same period lacked any narrative autonomy, meaning that someone would often have to stand next to the screen during showings and provide a context for the images, which went by like slides. “But Reis’s film has an internal narrative in the form of subtitles that clarify situations or tie them together,” the British researcher says.

Henley explains that the term “documentary” took root in the early 1930s to refer to the work of Robert Flaherty, especially *Nanook of the North* and *Moana*, both produced in the 1920s. “These films involve the dramatization of events, the invention of situations, and constant interference on the part of the director. For this reason, if they were shot today, they would not be considered documentaries,” he says. With the exception of a

Men (right) and women (next page) in one of the rare scenes where Reis directed the Indians in *Rituais e festas Bororo*



few isolated scenes in the film—for example, when the Indians are told to show their profile—Reis employs the filmmaking approach now known as an observational documentary style, in which the camera merely follows the action, without any apparent interference from the director.

Novaes argues that Reis was aware of his film's aesthetic potential. An example of this is the opening scene, in which a group of men are seen fishing among some bushes along a riverbank. Researchers note that opting for this frame rather than placing the fishermen in the foreground sparks the audience's curiosity about what the Indians were doing. In another kind of scene rarely found in documentaries back then, the director places the camera directly in front of the dancing Indians, allowing the viewer to observe details of their body adornments and affording a more intimate look at what occurs at that point in the ritual.

According to the researchers, other films from the same era that were produced in an ethnographic context were composed of single takes, had no narrative structure between scenes, and provided a literal, chronological view of the facts. This can be observed in the pioneering work of British anthropologists Alfred Haddon and Bald-

The documentary film should be interpreted in light of the climate of conflict between the Rondon Commission and Salesian missionaries

win Spencer and the Austrian anthropologist Rudolf Pöch. "It's remarkable how Reis made a film using a complex moviemaking language only 20 years after the first cinematic exhibition by the Lumière brothers in 1885," notes Novaes. Monte-Mór notes that Reis introduced aspects of indigenous community life in the film, shot panoramic images of the region, and showed rituals that preceded the burial in addition to the funeral itself. "Earlier ethnographic films recorded a dance or an Indian making ceramics, but made no attempt at narration," she emphasizes.

Eduardo Victorio Morettin, a professor of audiovisual history at the USP School of Communications and Arts, notes that works such as Reis's had a limited reach, while Flaherty's films enjoyed broader circulation and were seen by the general public. "Of the films made in Brazil from the late 19th century through the early 1930s, fewer than 10% have survived," he says. Morettin believes that while it is possible that *Rituais e festas Bororo* was the first ethnographic documentary, it should not necessarily be categorically accorded this status. "Given the small number of remaining Brazilian films, naming one work or the other as the first is always risky, because we don't fully know what was circulating back then."

Documentary filmmaker Aurélio Michiles, who directed a film that presents the career of Silvino Santos (1886-1970), one of the pioneers in the world of documentaries and director of the 1922 film *No paiz das Amazonas* [In the land of the Amazons], asserts that Flaherty's works cannot in fact be considered ethnographic since they



recreate the climate of the culture instead of registering it from an observational stance. “On the other hand, today we can state that every single movie, fiction or documentary, when stored in a film library, becomes a source of anthropological and ethnographic references,” Michiles says. He argues that Flaherty’s films should be thought of as documentaries precisely because they offer the audience a view of this cultural universe, even considering how the director intervened in the reality he intended to portray. “Every documentary filmmaker intervenes in reality. The people who are filmed are never the same in front of a camera,” he contends. Michiles also explains that Reis’s filmography has been better preserved than that of other filmmakers, such as Silvino Santos, favoring research that investigates the importance of the former’s filmmaking path. Other films by Reis include *Os sertões de Matto Grosso* [The backlands of Matto Grosso] (1912); *Ronuro, selvas do Xingu* [Ronuro, the jungles of the Xingu] (1924); *Viagem ao Roraima* [Journey to Roraima] (1927); *Parimã, fronteiras do Brasil* [Parimã, the frontiers of Brazil] (1927); *Os Carajás* [The Carajá Indians] (1932); *Ao redor do Brasil – Aspectos do interior e das fronteiras brasileiras* [Around Brazil: features of the Brazilian interior and frontiers] (1932); and *Inspetoria de fronteiras* [The inspectorate of borders] (1938).

CLASHES WITH THE SALESIANS

Cunha explains that given its distinct cinematic nature and narrative, the film should be interpreted in light of the climate of conflict between

the Rondon Commission and Salesian missionaries. “Newspapers published in the early 20th century feature articles by Rondon criticizing the missionaries. There was a dispute that was meant to sway public opinion about what the government should do with the Indians,” the researcher says. With this in mind, Cunha notes that Reis’s documentary portrait of the Bororo emphasizes their traditional culture with the purpose of disseminating images of these Indians as untamed and pure in their savage authenticity. These characteristics went against Salesian principles, which sought to extinguish expressions of indigenous culture and incorporate native peoples into a project for a mixed-race, hard-working Christian nation.

Chiara Vangelista, a historian of Latin American anthropology at the University of Genoa in Italy, is an expert in Bororo history, particularly their relations with the Rondon Commission and Salesian missionaries. Vangelista says that both Rondon’s and the Salesians’ projects were aimed at protecting the Indians and paving their road to Brazilian citizenship. “However, the projects were diametrically opposed,” she says. Rondon’s initiative was infused with positivist thought, then widespread in the military. Positivism advocated the establishment of a free federation of independent states divided into two categories: western states, originating from the union of European, African, and American groups, and so-called Brazilian-American states, made up of tribal ethnic groups.

“Writings by Rondon and the chief proponents of his project constantly reaffirm the duty to protect but not to direct tribal groups,” says Vangelista. On the other hand, from the standpoint of the Salesian priests, if the Bororo were to attain Brazilian citizenship, they had to give up their culture entirely, be “civilized”, embrace Catholicism (Rondon was against conversion), and join the world of the whites as wage earners. “Relations between Rondon and the Salesians settled into a climate of ‘armed peace’, and military visits to the missions had a vague flavor of inspections,” she says in conclusion. ■

Scientific article

CAIUBY NOVAES, S. et al. The first ethnographic documentary? Luiz Thomaz Reis, the Rondon Commission and the making of *Rituais e festas Borôro* (1917). *Visual Anthropology*. v. 30, i. 2, p. 1-43. 2017.

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TACCA, Fernando de. *A imagética da Comissão Rondon*. São Paulo: Papirus, 2001.

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Film

Rituais e festas Bororo: www.youtube.com/watch?v=EIn6eKqMBtE

A labyrinth of inconclusive decisions

86% of Brazil's Federal Supreme Court decisions are responses to internal appeals

Márcio Ferrari | PUBLISHED IN MAY 2017

You need only follow the news to realize that Brazil's Federal Supreme Court (STF) now occupies a central position in this country's most pressing discussions. In recent years, the court's decisions have made a significant impact in the political realm, but the scope of its activities is actually much vaster. Established during the construction of the legal framework of the Republic, the court has as its primary purpose the verification of the constitutionality of the laws. In practice, however, it serves as the highest level of the Judiciary, having the last word on all matters that are considered significant for Brazil. Because its prerogatives are far-reaching, the Supreme Court is the recipient of a heavy flow of cases that challenge its ability to decide. In 2016, 90,713 new cases arrived at the STF. Even though it completed 80,297 cases during the period, there remained an accumulation of approximately 60,000 pending cases. This number has remained stable in recent years.

Despite the efforts by its 11 justices, it is relatively rare that the STF makes a final decision as to constitutionality; 86% of its decisions are procedural. In other words, their decisions are responses to internal appeals filed by attorneys for the disputing parties. "The court does not decide the constitutionality of those claims; instead, it focuses on stages and deadlines," says Joaquim Falcão, director of the Getúlio Vargas Foundation (FGV) School of Law in Rio de Janeiro and a former member of the National Justice Council (CNJ), a body that monitors and refines the power of the Judiciary and ranks below the STF. "The Supreme Court is flooded with inconclusive decisions and has become caught in its own labyrinth, at immense economic and political cost to Brazil," he says.

Falcão believes that the court's non-decisions are just as important as its decisions because they, too, result in "de facto" situations. This can happen, for example, when a case becomes statute-barred, which means that the result fa-

vors only one of the sides. An example cited by Falcão in his study "O Supremo, a incerteza judicial e a insegurança jurídica" (*The Supreme Court, judicial uncertainty and legal insecurity*), published in the Portuguese edition of *Journal of Democracy*, are the suits that question the constitutionality of the government's economic plans. "It is estimated that more than 957,000 cases are languishing undecided in the lower courts, awaiting a decision by the Supreme Court that could impact the banking sector to the tune of more than R\$2.5 billion," the researcher notes. "That non-decision affects the principle of separation of powers and, by protecting the Treasury as one of the parties involved, makes the Supreme Court a true architect of economic policy."

"Brazil's economic plans benefit far more from the silence of the Supreme Court justices than from decisions that affirm their merits," observes Diego Werneck Arguelles, a professor at FGV Law-Rio. "It can be argued that this silence





was pre-arranged to avoid the responsibility of making decisions that would have a major political impact, and there is tremendous obscurity surrounding formation of its agendas, which customarily stalls the functioning of the court.” According to Arguelhes, “we are never certain about what the Supreme Court is going to rule on until the moment when the judgment begins, even though the agenda is published in advance.” The time factor upsets the agenda, and the chief justice is not required to provide an explanation as to when a certain case will be taken up again. Rarely can the full agenda be addressed in a single session, and the next session will not necessarily pick up where the court left off on the docket provided earlier.

In his article, Falcão points out that a natural state of uncertainty prevails, created by the expectation that decisions will be made by the Judiciary. This uncertainty stems from the Supreme Court’s failure to follow rules—or even to establish them. One example is the petition for

vista (petitions to examine the case file), a tool that has been examined by Arguelhes and Ivar Hartman, his colleague at FGV Law-Rio, and that is used by individual justices. They may ask for time to further examine the record; in the meantime, no further action can be taken. The internal rules of the court establish a time limit of 10 days, which can be extended for another 10 days before the case file must be returned, but more than five years has elapsed for some proceedings. Falcão calls use of this ploy “pathological” because it

unnecessarily extends the parties' right to "reasonable duration of the proceedings" as guaranteed by Article 5 of the Constitution. "Faced with its labyrinth of appeals, the STF eliminates some uncertainties and creates others. It's a perpetual motion system."

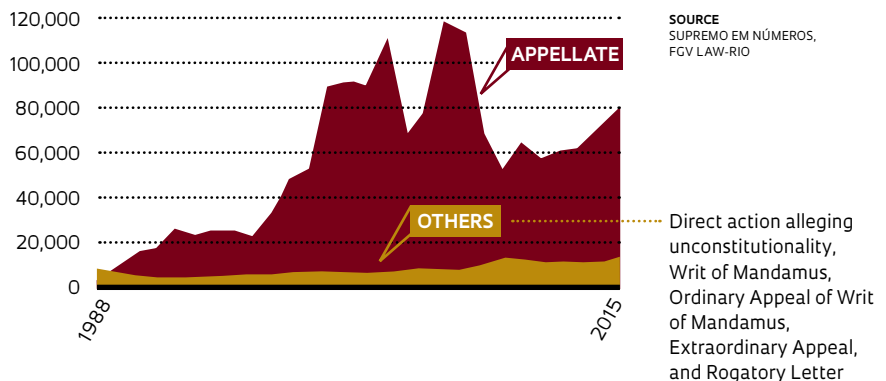
The conclusions reached by Falcão are based on quantitative data from projects entitled, "O Supremo em números" and "História oral do Supremo" (*The Supreme Court in numbers* and *Oral history of the Supreme Court*), both by FGV Law-Rio, as well as the project, "Justiça em números" (*Justice in numbers*) by the CNJ. All are available online. According to this researcher, the quantifications and the cross-checking of data extracted by software developed in "O Supremo em números" revealed that hundreds of cases remain at a standstill.

The group coordinated by Falcão advocates that studies about the Judiciary not be limited only to philosophical issues but also consider the sociological, economic, and cultural implications of court decisions. One example of the ignorance of the realities of the Supreme Court was the provision, in the text of the new Code of Civil Procedure as submitted for presidential approval in 2015, granting each party 15 minutes in which to submit their arguments on appeals heard at the STF. According to "O Supremo em números," an average of 9,402 such appeals reach the court every year. Therefore, for just one of the parties to use its 15 minutes would consume 2,350 hours a year. Warned of the problem, then-President Dilma Rousseff vetoed the rule.

Under the 1988 Constitution, the Supreme Court acquired unprecedented power that gives it, if there is sufficient demand and the justices find it necessary, the final word with respect to actions taken by the Executive and Legislative Branches and the lower levels of the Judiciary. The Constitution opened a significant number of routes for procedural access to the STF: a total of 36, between actions seeking a determination of constitutionality and different types of appeals. The prerogatives of the court can extend to the point that it recently reviewed and denied the most recent appeal filed to contest the outcome of the 1987 Brazilian Soccer Championship! In light of the profusion of claims, monocratic decisions (those handed down by

Activities at the Court

Volume and kinds of new cases at the STF (1988-2015)



The studies were made on the basis of quantitative data on projects by FGV-Rio and the CNJ

a single justice rather than a panel) prevail in approximately 93% of the cases each year. Researchers stress that this situation distorts the collegial nature of the STF and impairs the right of the disputing parties. Furthermore, when a justice hands down a preliminary decision, it suspends the entire proceeding and keeps it safe from a final decision by the full court.

Could the comprehensive scope of the Judiciary in Brazil, as implemented through the STF, be a way of dominating the other branches by affecting the democratic equilibrium among them? Not in principle, although that balance is a delicate one. "The Supreme Court has a decisively important role, but it is

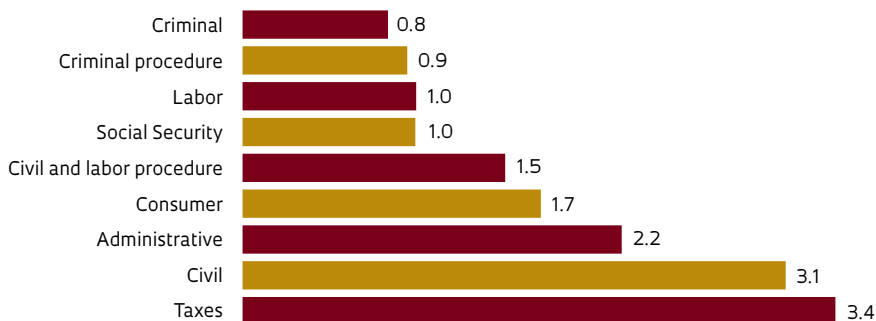
typical of the dynamics of the separation of powers that the boundaries are permanently under tension," says Rogério Arantes, a professor at the Political Science Department of the University of São Paulo (USP). "But the STF has to be restrained in its decisions, otherwise they may be disregarded. We need only remember the episode in 2016, when Senator Renan Calheiros refused to receive the order removing him from the presidency of the Senate, only to have the court reissue it within a few days to make it enforceable."

However, argues Oscar Vilhena Vieira, director of the FGV School of Law in São Paulo, because we have an "ambitious" Constitution, every legislative change or adoption of public policy acquires a constitutional dimension. "The Supreme Court is called on to give the last word on topics that should be resolved in the political realm," he says. The other branches delegate to the Judiciary the onus of making the most controversial decisions. Vilhena cites as examples gay marriage, striking by civil servants, and the tax wars among the states.

Falcão points to a "culture of proceduralism" that has not been shattered by attempts to reduce the demands on the STF, such as Amendment 45, enacted by the Brazilian Congress in 2004 and adopted by the court in 2007, which created the institutions of "general repercussion" (*repercussão geral*). "General repercussion" permits prioritizing cases according to their social importance and the binding precedent (by which a

A long wait

Average duration (in years) of preliminary rulings, by subject (1988-2013), one indicator of sluggishness at the STF



SOURCE SUPREMO EM NÚMEROS, FGV LAW-RIO

prior decision establishes case law for subsequent claims). However, although in the initial years of its effectiveness the “widespread effect” rule did in fact reduce the inventory of actions pending decision, that result was ephemeral. “General repercussion creates new internal reactions and more appeals, rules, and procedures that take up time,” Arguelhes warns. “If the STF were faithful to the precedents it establishes, the instrument of ‘general repercussion’ would not even be necessary,” says Damares Medina, a professor at the Brazilian Institute of Public Law and coordinator of research at the Open Constitution Institute (ICONS). “Even the cases decided under ‘general repercussion’ are re-tried by this court which, out of habit, always finds a reason to do so.”

“Congress tried to curb the number of claims but the devotees of proceduralism of the Supreme Court did not allow it,” Falcão concludes. There is, he says, historical resistance toward limiting the number of cases that reach the STF. This derives from a “selective importation” of the concept of judicial review—judicial control of laws according to the demands of society, which is a guiding principle of the Supreme Court of the United States and inspired the creation of the STF by the Brazilian Constitution of 1891. Falcão observes that there has been a failure to accompany the developments that have occurred in constitutional law in the United States in recent years, particularly the mechanism of writ of certiorari, the U.S. Supreme

Court’s prerogative to decide whether or not to hear a case without providing any justification for doing so. In Brazil, there is no statutory provision for such a decision or any tradition of returning cases to lower courts without ruling on them. The nature of the STF is somewhat hybrid, which makes it at once the guardian of constitutionality and the court of third instance—in most countries two instances are sufficient—and, in the case of trials of politicians who in Brazil enjoy special jurisdiction, it serves as a criminal trial court.

HISTORICAL REASONS

Falcão mentions historical reasons for the resistance to using case law to create filters. He notes that the STF was important during periods of authoritarian rule in Brazil, when it defended civil liberties and devoted itself to curbing abuses perpetrated by other spheres of power. “The jurisdiction of the STF in criminal law, for example, was influenced by that need.” Another factor behind the infrequency of refusals to hear cases is said to be “a concept that is mistaken, but culturally deep-rooted, that the reiteration of the existence of a State of Law by continual decisions enhances society’s impression that justice is being done.”

Damares Medina calls attention to the absence of consistent standards for reproducing Supreme Court case law. She says that this characteristic trait of decision-making behavior by the court encourages more filings and the re-evaluation of theories advanced in cases al-

ready decided. “Looking at Supreme Court case law, we find that one of the deleterious effects of the inconsistency in the patterns of reproduction of the court’s decisions is the multiplier effect it has—the re-opening of cascades of claims at the original courts of origin (case law at the base),” she says.

Medina argues that the Judiciary has become an end in itself. “In Brazil, there are almost 130 million court cases, more than 451,000 civil servants and a budget equivalent to 1.34% of GDP, while in the United States, Germany, and Spain that fraction does not exceed 0.30%,” she reports. One factor that helped create this swollen bureaucracy, Arguelhes and Medina recall, is that it is relatively inexpensive to take a dispute to court in Brazil and to pursue matters all the way to the highest level. In the cases of persons entitled to special jurisdiction, Falcão notes, cases can drag on for as long as 11 years. According to a survey included in “Supremo em números,” between January 2011 and March 2016, only 5.8% of the decisions made on investigations at the STF resulted in criminal prosecution and fewer than 1% of the defendants were convicted. “That is why legislators resist giving up their right to special jurisdiction,” Falcão says. “In all areas where the STF is active, the statistically most likely outcome is postponement.”

The situation has not escaped the notice of the members of the STF. Although they are discussing proposals for change, there is a stubborn attachment to all of its present prerogatives, researchers say. “Discouraging litigiousness, reducing the number of cases, decentralizing to lower courts the authority to give the ‘last word,’ controlling the behavior of the justices to make the timing of decisions predictable—all such measures would impact and diminish the power of the Supreme Court,” Falcão says. “It is a parallel and informal power not anticipated in the Constitution.” ■

Scientific articles

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From the factory floor to

Researchers
review the
history of the
struggles of
Brazil's feminist
movements

Danilo Albergaria

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For the last 100 years, the feminist struggle for equality and women's rights has impacted the Brazilian political scene. From strikes in 1917 to today's political pressure groups, women have had to fight hard to have some of their demands met. Recent surveys have deepened our understanding of different periods in that history. Some of those writings are found in the book *50 anos de feminismo: Argentina, Brasil, and Chile* [50 years of feminism: Argentina, Brazil, and Chile] (Edusp, 2017), which is the result of a project coordinated by sociologists Eva Blay, from the School of Philosophy, Literature and Human Sciences at the University of São Paulo (FFLCH-USP), and Lúcia Avelar, from the Center for Studies on Public Opinion at the University of Campinas (CESOP-Unicamp). The book helps readers understand the central role that feminist

organizations play in achieving legal and social protection for women. Looking only at the private realm, one sees essential victories, such as the elimination of a father's rights over his adult daughter and the criminalization of domestic violence and sexual harassment.

Despite this progress, Brazilian women are still underrepresented politically. According to the Inter-Parliamentary Union, Brazil stands 154th in a ranking of 190 countries with regard to the female presence in their legislatures. Only one of every 10 seats in the 513-member Chamber of Representatives is held by women. In the Senate, that presence is 14% of the 81 elected members. On this issue, Brazil ranks below even Saudi Arabia, with its long history of restricting women's rights and freedoms. According to Lúcia Avelar, Brazil's feminist organizations serve as a sort of forum for extra-



the floor of Congress

parliamentary representation of women; their activities are coordinated with small but active female delegations.

Political scientist Patrícia Rangel, a post-doctoral researcher at the Free University of Berlin in Germany and co-author of one of the articles in the abovementioned book, argues that this organized political maneuvering led to legal changes that ensured equal treatment under the law for both women and men, struck discriminatory terms from Brazil's legislation, and enabled women to legally serve as heads of families. Rangel says that the fruits of that work include the expansion of paid maternity leave (1988), the passage of the electoral quota law in 1995 (which requires that 30% of candidates be women), the availability of sterilization in public hospitals (1996), the regulation on the care available for legal abortions in the

Unified Health System (SUS) in 1998, and the Maria da Penha Act (2006) against domestic and intra-family violence.

Avelar says that even with its low rate of female representation in the legislature, Brazil stands out as a country with one of the best-organized feminist movements in the world. "This mobilization has achieved a high degree of coordination among networks that form a bridge between society and the State. Networks such as the Congress of Brazilian Women and the World March of Women are internationally known," she points out. She identified the turning point in the degree of this organization: "the gradual entry of women into higher education and the formation of feminist non-governmental organizations (NGOs)."

Feminist victories in Brazil, especially with respect to activities in the public sphere, arrived

Protest March for Direct Elections Now! in downtown São Paulo in 1984 (*left*) and demonstrators during the World March of Women on the Anhanguera Highway (SP) in 2010

Exiles from dictatorships in Brazil, Argentina and Chile made contact with feminist movements in Europe in the 1970s

with the 21st century. “One big gain obtained from the government as of 2014 was the introduction of the Women’s Budget, which is unique among Latin American countries,” says Avelar. This is an item in the federal government’s budget that is used for actions that impact the quality of life of Brazilian women, including things such as health care, dealing with violence, and equality in the labor market. The effort to achieve this special mention in the budget was coordinated by the Center for Women’s Studies and Advisory Services (CFEMEA) to make it possible to monitor budgetary execution and ensure

that the appropriated funds are actually released for use in implementing government policies as defined in the Women’s Budget.

RESISTING AND EXILED

Some components of the feminist organization in Brazil emerged from women’s opposition to the military dictatorship (1964-1985). The intensification of authoritarianism, which primarily began in 1968, produced waves of exiles who were opponents of the regime. Many women made contact with feminists in other countries,

especially in France. From there, Brazilians and other Latin Americans who had also become expatriates because of the military coups in Chile (1973) and Argentina (1976) produced publications that were intended to serve as a forum for feminist debates in exile.

Those groups have recently been studied by sociologist Maira Abreu, who has a PhD in social sciences from Unicamp and published the book *Feminism em exílio* [Feminism in exile] (Alameda, 2016). The author shows how those groups constituted an important presence in the Brazilian community in France and formed an arena for the dissemination of feminist thought. When they returned to their countries of origin, many exiles brought that experience back with them and, to some extent, were able to influence the debates going on in Latin American feminist circles. “We should not think of it as merely an importation of ideas,” Abreu warns, “but rather as an encounter among trends in feminist thinking that had been born in different realities.”

Despite the growth in their organization, women continue to have little involvement in political party structures. Lúcia Avelar points to the oligarchic nature of Brazilian parties and the centralization of power within them as the main causes of this exclusion. She believes that the parties on the Left currently offer somewhat better political opportunities for women. “In parties that have roots in social movements, internal disputes among different camps improve the status of women because those parties are usually open to the emergence of new factions,” she says. Patrícia Rangel notes that political parties do not seem to understand that the presence of women is synonymous with democracy. “This has negative effects for women in general, since it is the party officials at different levels who determine who obtains access to institutionalized politics; they play an important role in changing the political system,” says Rangel.

For many years, politicians’ failures to understand the roles of women left women relegated to the status of supporting players and subordinates in political parties and labor unions, arenas in which they could have expected, for the sake of ideological consistency, a defense of egalitarianism. “The idea of confronting the patriarchy usually took a back seat to the political priority, which was the criticism of capitalism,” Rangel says. Eva Blay points out that there had been a widespread belief that the modernization of society would produce equality between men and women. “That mechanistic view was questioned as people later realized that modernization itself had retained the same patriarchal patterns, clothing them in new garments and reassembling patterns of domination, violence against women,

Bertha Lutz in 1925: one of the founders of the Brazilian Federation for the Advancement of Women in 1922





The Rio de Janeiro newspaper *A Manhã* campaigned in favor of women's right to vote in 1926

and inequalities in the workplace, including in terms of pay,” Blay argues.

Those questions came from the feminists of the 1970s, but the first transformations promoted by Brazilian feminists have much older roots.

LABORERS AND INTELLECTUALS

In the Brazil of the 1920s, women had no political rights and could not vote or seek elected office. To pursue an occupation outside the home, they needed their husbands’ authorization, and then they earned less than half what men were paid for performing the same duties. This situation did not begin to change until after workers began to protest, and organizations such as the Brazilian Federation for the Advancement of Women (FBPF), led by biologist Bertha Lutz (1894-1976), emerged.

The daughter of bacteriologist Adolfo Lutz (1855-1940), Bertha was born in São Paulo and studied in France, where she was influenced by the international explosion of feminism, which was centered on the campaign for universal suffrage. Founded in 1922, the FBPF is generally seen as evidence that feminism’s first steps in Brazil were taken only by women from economic and intellectually elite groups, that is, women who were disconnected from the reality of most female workers.

However, that was not exactly what happened. A study by historian Gláucia Fraccaro points to the importance of political actions by women from the working class and their indirect influence on feminist leaders and organizations in the 1930s. Fraccaro recently defended her thesis

entitled “Os direitos das mulheres: Organização social e legislação trabalhista no entreguerras brasileiro (1917-1937)” (*Women’s rights: Social organization and labor legislation in Brazil during the interwar period (1917-1937)*) at the Institute of Philosophy and Human Sciences at Unicamp.

Fraccaro argues that the lack of attention paid to the history of working women is one of the factors that helped confirm the general impression that Brazilian feminism originated in the upper classes. At the same time, the notion took root that the working class had been missing in action when the feminist movement was emerging. However, one of the sources of organized feminist activity in the pursuit of rights is found not in movements by women from the elite but in the protagonist role played by women laborers in the strike that brought São Paulo to a standstill 100 years ago.

The general strike of 1917 was a reaction to a decline in purchasing power, a deterioration in working conditions, and an increase in the exploitation of child labor in industry. As a response to World War I, the acceleration in the manufacture of exports weighed heavily on worker families, who were impoverished and exhausted by longer working hours. Women made up the largest share of the labor force in the textile industry and represented about one-third of the urban workforce. Furthermore, most of the minors exploited by industry were girls. “When male and female workers rose up in a series of strikes starting in 1917, the concept emerged that social rights are not neutral and should encompass the status of women,” Fraccaro says.

This struggle led to victories during the first Getúlio Vargas administration (1930-1945). During that period, the political actions of Bertha Lutz were indirectly influenced by demands from working women. “Women from the Brazilian Communist Party denounced in the press the lack of concern for female workers expressed by the FBPF,” Fraccaro recalls, “while the transnational network that the Federation had joined imposed an agenda that involved maternity leave, a prohibition against night work for women, and the right to vote.” The pressures exerted by these movements led Vargas to approve a decree in 1932 that responded to those demands, including through an equal pay law that was never enforced. ■

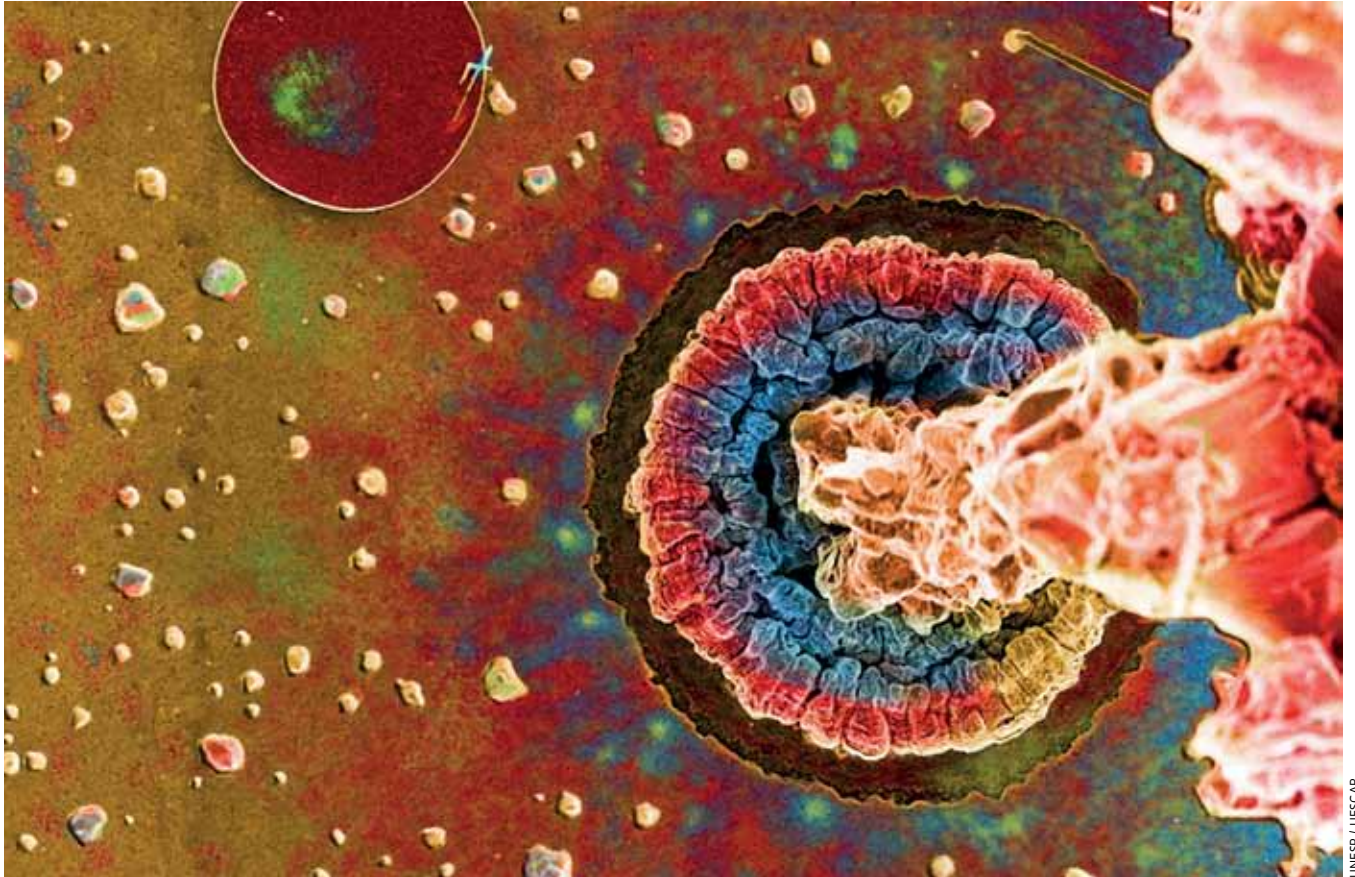
Project

50 years of feminism (1965-2015): new paradigms, future challenges (No. 12/23065-8); Grant Mechanism Thematic Project; Principal Investigator Eva Alterman Blay (USP); Investment R\$273,280.93.

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Diamonds in the sky

Tin oxide nanoparticles (*scattered fragments*) congregate in a cohesive circle, taking on the appearance of a volcano. The Functional Materials Development Center, directed by chemist Elson Longo, has developed a sensor for gaseous pollutants based on this compound. "Tin oxide is much more sensitive and selective than the available alternatives," says Longo. The photograph, entitled *Água da morte*, is part of the Nanoart series which was displayed at the Museum of Tomorrow in Rio de Janeiro.

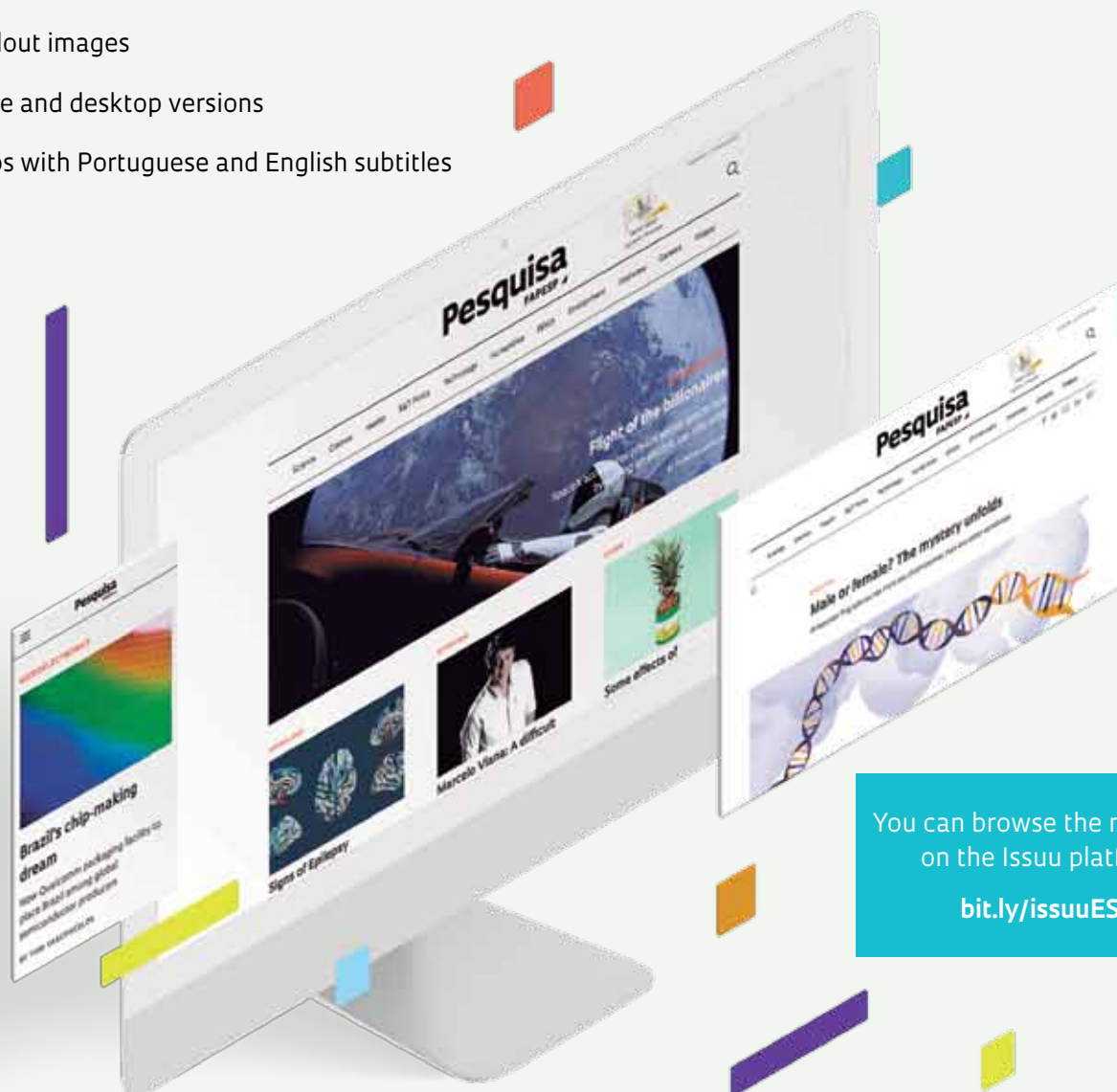
Image captured under a high-resolution scanning electron microscope by Rorivaldo Camargo, color added by Enio Longo and submitted by Elson Longo, professor at the Araraquara campus of Unesp

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