India

Space-travel success inspires the growing science and technology community, but financial difficulties create obstacles and industry is being called upon to take up more of the financial burden.

ARTICLE COUNT (AC): 1,483
FRACTIONAL COUNT (FC): 1,029.92
WEIGHTED FRACTIONAL COUNT (WFC): 921.77

On 24 September 2014, India's Mangalyaan probe started to orbit Mars, making it only the third country (after the Soviet Union and the United States) to reach the red planet. This milestone, along with the election of prime minister Narendra Modi on a platform that promised to promote and support scientific endeavour, seemed to bode well for technical advancements in India, but back on the ground much remains to be done.

Commentators point to a need to streamline lengthy and complex funding processes, clarify government rules and regulations, and increase the number of trained personnel in the science and technology industry. In July 2014, Modi's first budget delivered allocated research funding increases that lagged behind inflation—not a good start.

Anurag Chaurasia, a biotechnologist at the Indian Council of Agricultural Research, agrees with the need for infrastructure reform, but notes that positive steps have been taken despite funding constraints.

OUTSIDE INVESTMENTS

Despite government promises of improved financial support, India's science centres must often supplement funding from a range of other sources. For example, the TTK Centre for Rehabilitation Research and Device Development relies on grants from various organizations, including about US$600,000 over five years from the TTK Group, an Indian business conglomerate. These types of funding negate the vagaries of government grants, says mechanical engineer Sujatha Srinivasan, at the Indian Institute of Technology (IIT), Madras, and an instructor at the centre. "With [India's Department of Science and Technology and the Department of Biotechnology], it is a go/no-go scenario," Srinivasan says. "There is very little feedback." In contrast, she says, foundations follow a more rigorous grant process.

> "IT'S A CHALLENGE TO DELIVER THE ADVANTAGE OF DEVELOPMENT TO THE POPULATION"

Funding support from the TTK Group, however, does come through a circuitous government route, the Companies Act of 2013. Under a clause in this act successful companies are compelled to contribute 2% of their net profits toward addressing social problems in India. According to government data, there are at least five million people in India whose physical movement is impaired, and so the grant fulfils the criteria for bringing about change.

Indeed, government policy appears designed to procure even more funding from industry. India spends less than 0.88% of its GDP on science research compared with 2.76% for the United States and 4.04% for South Korea, according to the science and technology minister Harsh Vardhan in response to a question tabled in parliament. Vardhan also pointed out that only a third of India's funding is contributed by the private sector, a lower proportion than in many emerging countries.

CREATING CONNECTIONS

Even now some industry participants in India do contribute significantly to the research community. At the Indian Institute of Science (IISc) in Bengaluru, for instance, Kris Gopalakrishnan, a co-founder of the Indian IT company Infosys, is funding a brain research centre. To complement the centre, three chairs in computational brain research have been set up at IIT Madras. The first occupant is Partha Mitra of Cold Spring Harbor Laboratory in New York, whose group is attempting to map neuroanatomical circuitry in the mouse brain.

Mitra will set up collaborations between IIT, Cold Spring Harbor and IISc. In return, he gets substantial computing power from the Indian institutes for his data analysis. "I think it's kind of overdue to build up computational brain research in India," says Mitra, who will

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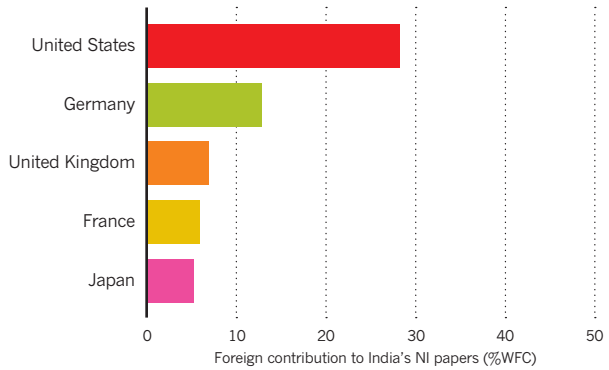
Top ten institutions
Even among India's leaders on the Nature Index (NI) WFC, the volume of publishing never gets very high and falls off fast.

RANK	INSTITUTION	WFC 2014	AC 2014
1	Indian Institutes of Technology (IITs)	168.17	287.00
2	Council of Scientific & Industrial Research (CSIR)	128.64	196.00
3	Indian Institute of Science (IISC)	93.72	149.00
4	Indian Institute of Science Education & Research (IISER)	75.88	106.00
5	Indian Association for the Cultivation of Science (IACS)	49.95	70.00
6	Tata Institute of Fundamental Research (TIFR)	29.63	199.00
7	Jawaharlal Nehru Centre for Advanced Scientific Research	24.13	43.00
8	Harish-Chandra Research Institute (HRI)	19.47	40.00
9	University of Hyderabad (UoH)	19.04	28.00
10	Saha Institute of Nuclear Physics (SINP)	15.45	100.00

Top five collaborators
Among India's NI articles that include international collaboration (about 40%), few include scientists in other Asia-Pacific countries.



act as visiting faculty and help students build networks.

Other science projects also depend on teamwork. The International Centre for Theoretical Sciences (ICTS) in Bengaluru, which emerged in 2007 from the theoretical physics department at the Tata Institute for Fundamental Research, focuses on collaborations. ICTS was modelled on the Kavli Institute for Theoretical Physics in Santa Barbara and the Institute for Advanced Study in Princeton, New Jersey, the revered home of Einstein and other luminaries. "ICTS is a centre where the international community congregates, interacts and collaborates with Indian scientists and students, to everyone's benefit," says its director Spenta Wadia, a physicist.

ICTS is also a nodal centre, along with others, for the proposed Laser Interferometer Gravitational-Wave Observatory India, an Indo-US collaboration to detect gravitational waves. So far, several of its key contributions help scientists solve physics problems, such as proofs of filtering techniques used in weather and climate prediction. Physical sciences already make up a focus of India's research, accounting for 40.5% of its articles in the 2014 Nature Index.

Developing an interdisciplinary institute requires a community. "Bengaluru provides the ecosystem," says Wadia, who had to lobby the government hard, and prepare a white paper explaining why ICTS should be set up here. The city (which until October 31, 2014 was officially known as Bangalore) is also home to the Jawaharlal Nehru Centre for Advanced Scientific Research, the National Centre for Biological Sciences, the Raman Research Institute and the Indian Space Research Organisation.

Although the ICTS has government support for building its infrastructure and facilities, like the TTK centre, it supplements this with grants from outside. For example, the French aircraft manufacturer, Airbus, funded a chair in the mathematics of complex systems (shared with the TIFR Centre for Applicable Mathematics).

JOERG BOETHLING/ALAMY

Transgenic cotton must be optimized to be resistant to crop-destroying pests in India.

"These grants — over and above government grants — are absolutely critical to fulfilling the mission of ICTS," says Wadia. "They also give you flexibility in what you do."

MAKING SCIENCE SOCIAL

Beyond just moving ahead in the lab, India needs to get results to the people. As Chaurasia says, "It is a challenge to deliver the advantages of scientific and technological development to the majority of the population, which is living below the poverty line." In particular, Chaurasia points out challenges in feeding India, which ranks 55th out of 76 countries on the United Nation's Global Hunger Index. The primary agricultural challenge facing India, Chaurasia says is "to develop climate-resilient, green, high-yielding, sustainable agricultural technologies that are affordable for rural areas." This is not one of India's strengths, because only 8.4% of its publications in the 2014 Nature Index address any kind of life science.

To achieve that, however, Chaurasia believes that the country must explore more of today's advanced options for farming, though past attempts have not been successful. In the early 2000s, for example, a pilot project of planting Bt cotton, which includes a gene for an insect toxin that comes from the bacterium *Bacillus thuringiensis* (Bt), was ineffective in resisting bollworms because the cotton was a hybrid from Western countries in which the toxin was not concentrated highly enough. The lesson learned, says Chaurasia, is that India must "develop indigenous transgenic crops — genetically modified organisms — especially after the failure of the Indian government-led Bt-transgenic programmes." Developing transgenic hybrids optimized for India, though, will probably require the nation's industry taking up the challenge.

Chaurasia believes that the government must take a bigger part and "enhance all-round investment in agriculture without surrendering to private interests." In particular, private interests from outside India, such as US-based Monsanto, received some of the blame for past failures with transgenic crops. Chaurasia also calls for other changes, including "attracting the best talents for agricultural research by reinventing the education system."

AMBITIOUS IDEAS

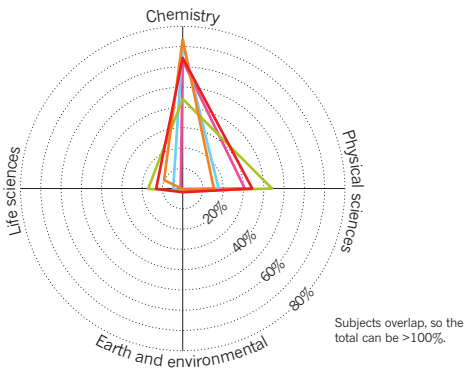
The progression of India's science and technology depends on finding routes for scientists to do world-class research. In virtually all cases, that requires funding from research institutes. Optical physicist, Pavan Kumar, at the Indian Institutes of Science and Research in Pune, says that the institute provides reasonable funding to researchers. For instance, a start-up grant can be in the order of US$200,000. Consequently, says Kumar, "You can think about ambitious problems that a starting principal investigator might be hesitant to think about." Even with existing funding issues, India placed 13th for global publishing output in the 2014 Nature Index.

Research like Kumar's easily branches between basic and applied. Such connections could be the key to better funding. At IIT, for example, Srinivasan is carving a niche between basic and industrial research, but she points out that her work may not lend itself to publication. Still, she says, "Everybody need not do the same thing. I have enough academic freedom to contribute in my own way." ■

INDIA ANALYSIS

- Indian Institutes of Technology
- Council of Scientific & Industrial Research
- Indian Institute of Science
- Indian Institute of Science Education & Research
- Indian Association for the Cultivation of Science

Institutional subject spread
Scientists at most of India's leading research centres focus on chemistry in papers in the NI WFC.



***Nature* and *Science* ratio**
Although other NI metrics show the low volume of articles from India, this one highlights the lack of quality.