



Domestic developments

Returnee researchers are aiding India's development. Why are they coming back?

BY T. V. PADMA

When Anil Koul told his friends that he would be moving to India to start working at a government research and development organization, most of the reactions were of disbelief, “even sympathy”, he says. “Some thought it was a crazy idea — moving from the world’s largest health-care giant to a governmental, bureaucratic set-up.”

Koul took charge of the Institute of Microbial Technology (IMTECH), in the northern city of Chandigarh, in 2016, relocating from Johnson & Johnson in Belgium, where he was senior director and head of the respiratory diseases group. The move to IMTECH — a branch of India’s government-run Council of Scientific and Industrial Research — was atypical. Few scientists return to India after holding top positions abroad, and fewer still move into the less-lucrative public sector.

The scientific landscape that Koul has returned to is vastly different from the one he

left in 1998. India is now actively participating in and, in some cases, leading advances in pharmaceuticals, agriculture and energy. The country’s efforts in space exploration are a point of particular national pride.

India is preparing for its second Moon mission in 2018 after a successful maiden Mars mission in 2014, and is spreading its wings in international astronomy collaborations. The country will host the third laboratory of the Laser Interferometer Gravitational-wave Observatory (LIGO) project in Hingoli, while the National Centre for Radio Astrophysics in Pune is working on the design of the ‘Telescope Manager’ — the central command system of the Square Kilometer Array.

These could be signs that India is enjoying ‘brain gain’ — Indian researchers are returning to their country of birth with newly minted research skills gained while abroad. This is a far cry from the state of the country’s scientific

sector 40 years ago, when entire cohorts of graduates from India’s research institutes left for US institutions in search of better economic and educational opportunities.

“We are now in an era of globalization and international cooperation,” says immunologist Indira Nath, a member of the Indian National Science Academy. “Scientists going abroad is no longer a big issue.”

TO-DO LIST

But India still faces significant challenges. It is home to one-quarter of the world’s tuberculosis (TB) cases, and continues to be ravaged by mosquito-borne infections including malaria and dengue fever. Around 700 million Indians (56% of the country’s population) have no sanitation, 240 million have no access to electricity and 97 million lack clean drinking water. Natural disasters such as droughts, floods and storms — already common ▶

► across Southeast Asia — are set to increase in frequency and ferocity as the world's climate changes.

It falls on publicly funded research to take the lead in finding solutions. Since India gained independence from British rule 70 years ago, every prime minister has emphasized the role of science in the country's development. The current incumbent, Narendra Modi, told a meeting of leading Indian science officials in July that science, technology and innovation are the keys to the progress and prosperity of India and that the government aims to apply science to solve the country's problems. As various policy initiatives make clear, India is betting on science to address its pressing challenges in energy, environmental protection, food, water, sanitation, health care and unemployment.

To achieve this, the government is hoping to find more scientists like Koul, who sees his role as an "opportunity to address bigger social as well as scientific challenges".

This is a tall order, and there's an elephant in the room. Government funding for Indian research and development has stagnated at around 0.85% of gross domestic product for more than a decade, compared with at least 3% invested by technologically advanced nations such as Denmark, Japan and Sweden.

Koul is nonetheless optimistic, and has helped to forge a collaboration between IMTECH and Johnson & Johnson, announced in August. They will work in parallel on four new molecules as potential drug targets and explore shorter, safer and more-effective oral treatment regimens for various strains of TB.

BIOPHARMA STRIDES

Koul's collaboration is well placed to take advantage of the success of India's pharmaceutical industry. Building on the solid foundations of the country's expertise in academic chemistry, major pharmaceutical companies have set up factories to make affordable generic antibiotics, vaccines, and diabetes and HIV medicines.

This strength is paying dividends. According to Hyderabad-based Sathguru Management Consultants, India's pharmaceutical industry was worth US\$18.8 billion in 2010 and \$41.1 billion in 2017, and is expected to expand to an estimated \$72.4 billion in 2022. One-fifth of the world's generic drugs are made in India, and around half of this manufacturing is based in Hyderabad.

The production of generics has certainly helped the sector, but many people hope to see the country grow beyond manufacturing. "We now need to be recognized for new drugs that address unmet medical needs," says Kiran Mazumdar-Shaw, managing director of bio-pharmaceutical company Biocon in Bangalore. The firm's growing pipeline of biologics ranges from oral insulin for diabetes to monoclonal antibodies for use in cancer therapy.

"There is incredible potential within India to become a powerhouse driving biopharma innovation in the Asian market," says Vaz Narasimhan, himself a second-generation Indian American and chief executive of Novartis, a pharmaceutical company in Basel. The biopharma industry is increasingly looking for new types of talent, says Narasimhan. He gives the example of data analysts and mathematicians who he says are driving the next wave of medical innovation.

THERE IS INCREDIBLE POTENTIAL WITHIN INDIA TO BECOME A POWERHOUSE.

Narasimhan's confidence in Indian pharmaceutical development is significant. Most pharma companies have been reluctant to take on costly research and development to combat 'poor-man's diseases' such as malaria and TB, says Soumya Swaminathan, one of India's leading experts on TB.

Swaminathan was appointed deputy director-general for programmes at the World Health Organization in October. She has led an effort to consolidate India's fragmented TB research, previously supported by four separate institutions, under one umbrella organization — the IndiaTB Research Consortium. "These diseases are our problem," she says. "And it is pointless expecting Western pharma companies to be interested in them."

When asked, Indian pharmaceutical companies say they are reluctant to take up research in these areas, citing a lack of government funding for early-stage research, and reams of red tape once a product reaches clinical trials.

POLLUTION PAINS

In April, a collaboration between researchers in Germany and Anil Dayakar, an environmental activist in India, reported that Hyderabad's pharmaceutical manufacturing was polluting the region's water system to an "unprecedented" degree, and hurrying the development of drug-resistant forms of bacteria (C. Lübbert *et al.* *Infection* 45, 479–491; 2017). The researchers suggested that more regulation was needed to prevent further pollution in the region.

The pharmaceutical industry in India is not the only source of contamination — pollution is common to many of the country's cities, and India's capital, New Delhi, spends its winters wrapped in smog. Krishna Ganesh, director of the Indian Institute of Science Education and Research in Tirupat, hopes that science can

help. "The focus in chemistry is now shifting into areas that involve green and sustainable chemistry," he says. Research topics include non-toxic chemicals, environmentally benign solvents, organic production and renewable materials. "The main aim should be to get rid of toxic chemicals produced in industrial manufacturing," and to prevent gases escaping into the atmosphere, he says.

NANOTECH HOPES

India's strength in chemistry has aided its effort to become a leader in the interdisciplinary field of nanotechnology. It's an especially tempting area of research because there's a deep vein of funding to mine, says Kizhaeral Subramanian, a researcher in the department of nanoscience and technology at Tamil Nadu Agricultural University in Coimbatore. "Global funding for nanotech had increased from \$1 billion in 2000 to \$2 trillion in 2016," he explains. On top of that, Subramanian says that the country has a strong talent pool to draw from owing to the proliferation of nanotechnology degree programmes across the country.

From a developmental perspective, the field is a sensible focus as well. As India's population swells further, the demand for food and clean water is rising. "Nanomaterials can help in water cleansing from bacterial and metal contaminants," says Ganesh, and nanomaterials may also be able to help with crop protection. For example, Tamil Nadu Agricultural University is researching the production of non-toxic herbicides and fertilizers, as well as emulsions and films that improve the shelf life of fruits and vegetables.

ENERGY DARK HOLES

Of India's 1.3 billion citizens, almost 20% still lack electricity. To help combat this, the country has launched an ambitious renewable-energy plan, broadly focused on solar and wind power. Overall, the country hopes to produce 175 gigawatts from renewable energy sources by 2022 — meeting around 20% of the country's predicted electricity demand.

According to Tata Narasinga Rao, associate director of the International Advanced Research Centre for Powder Metallurgy and New Materials in Hyderabad, India enjoys between 250 and 300 clear sunny days each year — ideal for solar technologies. The energy plan is helped by cheap land, a vast pool of talent to draw from and enthusiastic government support and infrastructure, says Rao. In a review published this year, the International Renewable Energy Agency lists India among the six countries — with Brazil, China, Germany, Japan and the United States — that accounted for most of the renewable-energy jobs in 2016.

One research programme, the Solar Energy Research Institute for India and the United States, brings together the Indian Institute of Science in Bangalore and the National Renewable Energy Laboratory in Denver, Colorado,



Meenakshi Diwan works on a solar panel in India's Odisha state in 2009 — then part of a burgeoning solar grid with a capacity of less than 10 MW. Now, India has a solar capacity of more than 6,000 MW.

to accelerate the development of solar electric technologies by lowering the cost of production.

As part of this venture, scientists developed a new nanotechnological solar absorption system in 2015. The prototype, Rao says, costs half as much as the non-vacuum tubes currently used in solar collectors worldwide and have enormous potential for industry.

There are local quirks to take into account before any company starts cashing in on a solar goldmine. Manufacturers still haven't worked out what to do about monkeys and rats, which relentlessly and indiscriminately chew telephone, electrical and fibre-optic cables across the subcontinent.

Meanwhile, Indian researchers are using crop residues, normally burnt as waste by farmers, to develop advanced biofuel systems and products such as biogas and biomaterials. "India's strong knowledge base in biotechnology, chemistry, engineering and process engineering can be tapped to do research in the biofuel sector," says Ahmad Kamal, a chemist at the Indian Institute of Chemical Technology in Hyderabad.

CALLING YOUNG SCIENTISTS BACK

To achieve its grand ambitions, India needs to nurture its new-found brain gain, and is fighting to make itself as attractive as possible through the Department of Science and Technology (DST), one of India's largest research-funding agencies. In June, for example, the DST announced endowments of \$10,000 a month for researchers who choose to move to India from labs overseas.

Lipi Thukral, a computational biologist at the Institute of Genomics and Integrative Biology in New Delhi, thinks that the Indian research sector has been unfairly stereotyped

abroad. "It is a myth that Indian salaries for scientists are low. They are very good when one factors in the purchasing power of the rupee," she says. "One can do great science here, too."

Thukral uses high-performance computers to study the movement of biological structures and to model protein folding. After a PhD in Germany, and a postdoc in the UK, she returned to India in 2012 under another DST scheme.

Shalini Gupta, a chemical engineer at the Indian Institute of Technology Delhi, returned to India in 2009 after earning a PhD in chemical and biomolecular engineering from North Carolina State University, in Raleigh, and a postdoc from Imperial College London. Gupta's team is working on cheap, portable medical tools to rapidly diagnose sepsis, a serious complication of many bacterial infections. For her, India makes the perfect laboratory. "We have the advantage of having ready access to patients, samples and field trials."

Meanwhile, the Indian government plans to develop 20 existing universities into 'world class' research institutions with an incentive of \$1.54 billion of funding. Policymakers hope this will free the country's best universities from reliance on the country's grant commission and associated red tape, and encourage greater institutional autonomy.

"There are always challenges in working in a third-world country, but India's role in the development of next-generation technology cannot be ignored, especially in the fields of pharmaceuticals, agriculture, energy and environment," says Gupta. "If you are situated close to a problem, you have a bigger advantage in terms of solving it." ■

T.V. Padma is a science journalist in New Delhi.

About IISc



Indian Institute of Science

The Indian Institute of Science (IISc) was established in 1909 by a visionary partnership between the industrialist Jamsetji Nusserwanji Tata, the Maharaja of Mysore, and the Government of India. Over the 108 years since its establishment, IISc has become the premier and highest-ranked institute for advanced scientific and technological research and education in India. IISc has been ranked at the 8th position in the 2017 Times Higher Education ranking of the world's best small universities. Faculty members at IISc carry out research, in all contemporary areas in science and engineering. The forty departments and centres of IISc are organised into the Divisions of Biological, Chemical, Electrical, Mechanical, and Physical & Mathematical Sciences, and the recently created Division of Interdisciplinary Research. The Institute's academic programs are highly sought after; they include PhD programs in all these divisions, masters' programs in engineering, and a unique multidisciplinary undergraduate program.

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The Institute welcomes applications from exceptionally bright, motivated individuals with an established record of independent, high quality research, and commitment to teaching, for the positions of **Assistant Professor** and **Associate Professor**, in all disciplines of interest to the Institute, in the fields of science and engineering.

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Women candidates and applicants belonging to the Scheduled Castes, Scheduled Tribes and OBC are especially encouraged to apply.

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Located in the National Capital Region of Delhi on a vibrant 286-acre residential campus, the six-year old University houses a diverse student body representing 27 states of India. Designed to be one of India's leading multidisciplinary, research-focused institutions of eminence, it currently has disciplinary Departments under the umbrellas of four Schools: Natural Sciences; Engineering; Humanities & Social Sciences; and Management & Entrepreneurship; as well as a School of Extended Education

& Professional Development to support life-long learning. Additionally, a lot of innovative and contemporary research is facilitated at the interdisciplinary Centers of Big Data Analytics; Environmental Sciences & Engineering; Public Affairs & Critical Theory, etc.

Research is an integral part of the pedagogy at the University. The emphasis is on 'learning by doing', so that the students develop the essential skills of creative problem-solving which equip them to face the challenges of tomorrow's world.

The state-of-the-art infrastructure supports cutting-edge research in

science and engineering. Some of the life-changing advances made by our researchers include identification of novel biomarkers in neurodevelopment and neurological diseases; development of molecules that reverse the effects of heavy metal poisoning; advancement in understanding the basic biology of the malaria parasite; development of a technique to precisely control the number of layers of graphene; and developing a protocol to sense pathogens using organic bio-electronic devices.

The University provides a platform for academic entrepreneurship and cooperation. It has recently been selected for hosting an Incubation Centre under the government's prestigious 'Atal Innovation Mission'.

Our commitment is to creating knowledge and solutions that

serve national and global needs. One such initiative is in the area of Water Science and Policy, where policymakers rub shoulders with scientists and engineers to create the necessary language and tools.

The University received the "University of the Year" award ('in existence for less than 10 years' category) from the Federation of Indian Chambers of Commerce & Industry in 2016. We are on the right track, but no institution can work in an isolated bubble today – based on our strengths, we are establishing the essential ecosystem of collaborators, partners and well-wishers, across sectors, disciplines and geographic boundaries, to deliver the dream! ■

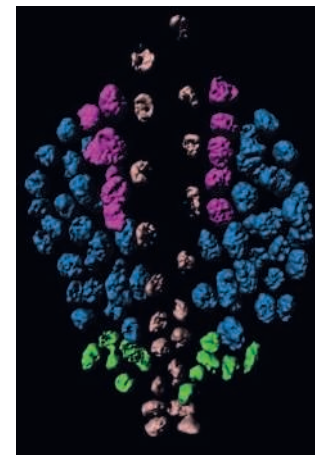
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The Wellcome Trust/DBT India Alliance is a visionary partnership funded equally by the Wellcome Trust, UK, and the Indian government's Department of Biotechnology. It aims to build excellence in the Indian biomedical research community by identifying and supporting future leaders in basic, clinical and public health research for improving human and animal health.



Since its inception in 2009, the fellowship programme has awarded 280 fellowships at 82 different institutions in 29 Indian cities. About a third of the Fellows are women and about a quarter do clinical and public health research. The focus is on funding the best people early in their careers and set them on a leadership track.

Besides supporting exceptional biomedical research scientists at Indian institutions through fellowships and a continuous system of engagement and mentoring, India Alliance aims to build a strong research ecosystem in India that can drive innovations to tackle health challenges, and inspire the next generation of researchers.

Training workshops for biomedical scientists and clinicians

Science Communication workshops

To train Indian scientists in communication, the India Alliance conducts one-day SciComm101 and two-day SciComm workshops. Since 2011, more than 2,000 PhD students, postdoctoral scientists and clinicians from around 100 institutions have received communication training through these workshops. In 2016, India Alliance formed a partnership with Nature India and Nature Jobs (India) for Science Communication and Career workshops, held in tandem with major scientific meetings. In 2017, India Alliance and Nature India held a two-day workshop Visualising Science that armed scientists and those in allied fields

with visual tools and methods to convey their research more effectively.

Research Leadership workshops

Leadership and management skills are critical for a successful science career. India Alliance organizes leadership workshops for its Fellows and other young Indian researchers to help them recognize and develop their leadership style, and gain critical lab management and communication skills.

Developing Indian Physician Scientists (DIPS) workshops

India Alliance launched Developing Indian Physician Scientists (DIPS) workshops in 2017 to ignite the research interests of young doctors, while promoting an understanding of the frontiers of medicine and

related sciences. The workshops, presented by eminent physician-scientists, provide training in quantitative methods and research methodology, and an opportunity to discuss biomedical research and career options.

Supporting interdisciplinary scientific meetings in India

India I EMBO Symposia

The India Alliance and European Molecular Biology Organization (EMBO) co-fund up to three meetings per year in India to address interdisciplinary discovery and innovation.

Public Engagement

Connecting science to society

The India Alliance also aims to improve science and health understanding through engagement activities while bringing scientists and the public together to debate, deliberate and collaborate on issues affecting human health. India Alliance regularly organizes public events in different Indian cities and supports its Fellows, and organizations that undertake public engagement activities. ■

For more information on India Alliance programs visit www.wellcomedbt.org



Training workshops for scientists and creative public engagement programs are central to India Alliance's vision of building a robust biomedical research ecosystem in India. Top image represents hematopoietic stem cells (purple), progenitor cells (blue), niche cells (green) and cardioblasts (orange) in a Fruit fly.

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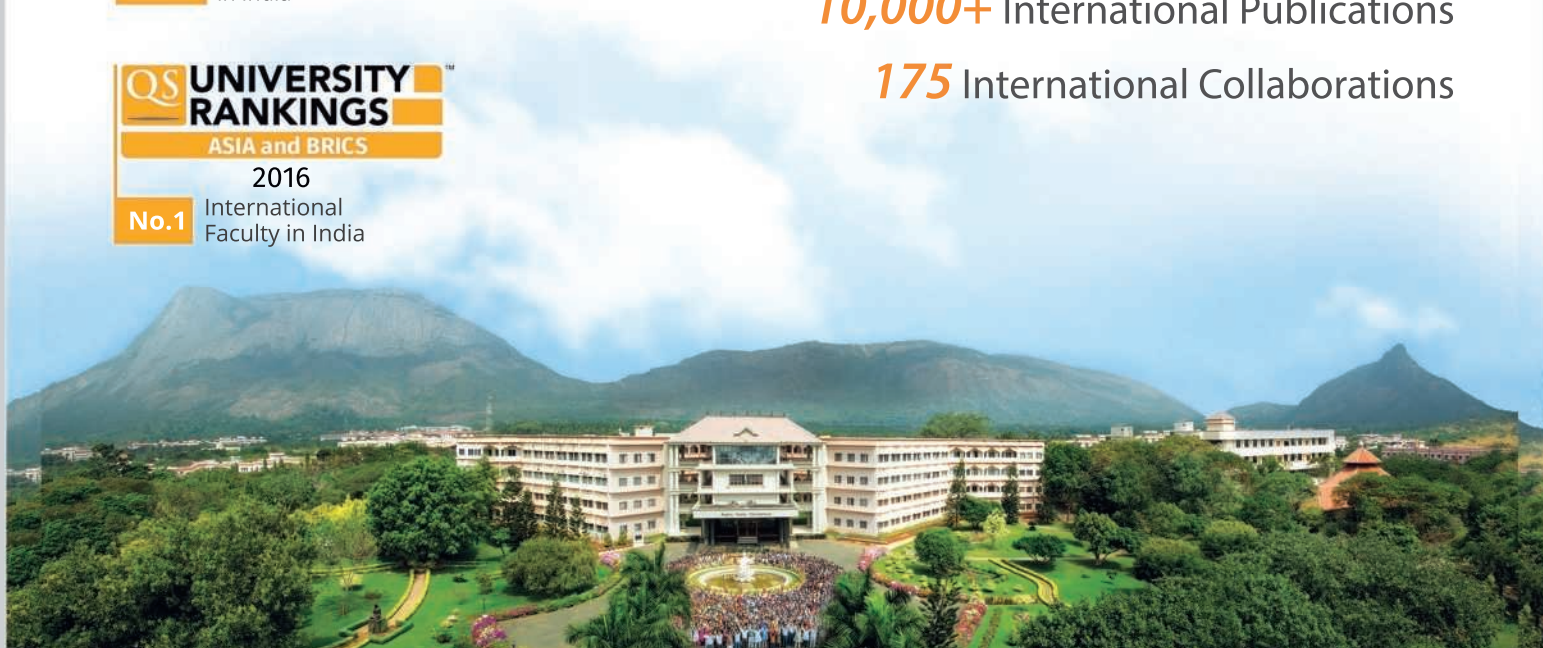
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