

Research

Horizons

Pioneering research from the University of Cambridge

Issue 28

Special issue on
India

Featuring
Democracy
Energy
Health
Water
Education
Art
Manufacturing
History
Innovation
Religion
Earthquakes



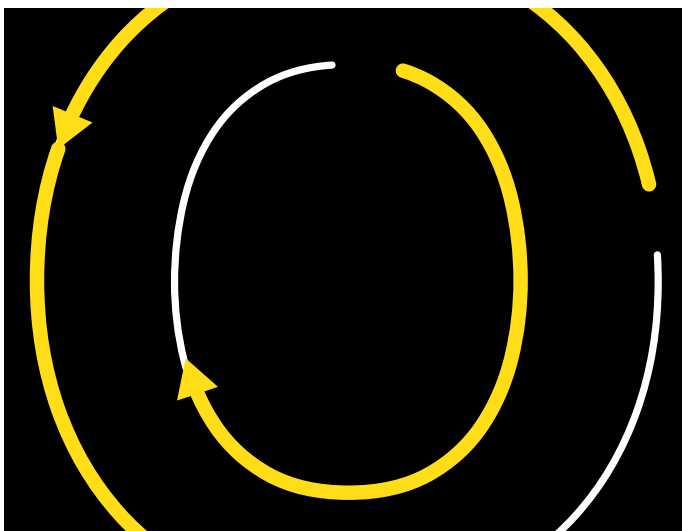
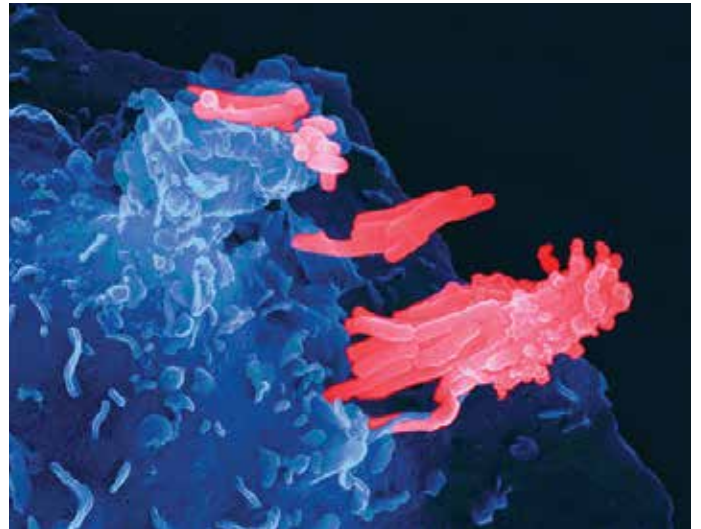
**UNIVERSITY OF
CAMBRIDGE**

www.cam.ac.uk/research

Contents

A Features

4 – 5	Sanskrit Manuscripts Project	20 – 21	Cambridge's engagement with India
6 – 9	A whole host of options	22 – 25	A democratic cacophony
10 – 11	Education that adds up	26 – 27	Earthquakes without frontiers
12 – 13	A touch of frugal genius	28 – 29	A world of science
14 – 15	<i>Man with a Bouquet of Plastic Flowers</i>	30 – 31	Phone for a doctor
16 – 17	Not a drop to drink	32 – 33	Spiritual violence and the divine revolution
18 – 19	Keeping the supply chain flowing	34 – 35	Mirage maker



B Things

36 – 37 The sad sailor and *The Sea-Pie*

C Inside out

38 – 39 Extreme sleepover: The mystery of a damp bed



Editor

Dr Louise Walsh

Design

The District

Editorial advisors

Professor Joya Chatterji, Dr Bhaskar Vira, Dr Toby Wilkinson

Writers

Craig Brierley, Alex Buxton, Sarah Collins, Fred Lewsey, Stuart Roberts, Louise Walsh

T +44 (0)1223 765 443

E research.horizons@admin.cam.ac.uk

W cam.ac.uk/research

Welcome

This issue of *Research Horizons* is devoted entirely to India.

In 2010, following the announcement of his appointment as Vice-Chancellor of the University of Cambridge, Professor Sir Leszek Borysiewicz was asked to join a Prime Ministerial delegation to India. I was standing on a train platform when he called, asking for an analysis of our existing collaborations in India. What emerged surprised him, members of the University and many in India: well over 100 collaborations and partnerships, many forged over decades, others more recently. In providing this data, several academics expressed how they would welcome better recognition from the University of the value of these partnerships.

A lot has happened in five years, much of it thanks to the continued support of the Vice-Chancellor. We now lead 15 UK–India Education and Research Initiative (UKIERI) partnerships ranging from social healthcare to rural agriculture. Our conference on ‘Nehru and Today’s India’ was broadcast live on NDTV. Our work on multi-drug-resistant tuberculosis has been recognised in laboratories co-located in Chennai and Cambridge, funded by the UK Medical Research Council and India’s Department of Biotechnology (DBT). The first postdoctoral fellows, based at the National Centre for Biological Sciences in Bangalore and Cambridge, started this autumn. Annually, we test progress and seek advice from our India Circle of Advisors, based in India. To sustain our work, we are establishing a Section 8 Company in India, which will receive funds in India to support partnerships in India. And we are currently recruiting to the first five Fellowships funded jointly by Cambridge and DBT, in a new model whereby a Cambridge-appointed researcher spends 60% of their time in India, integrating their work with colleagues in India and Cambridge.

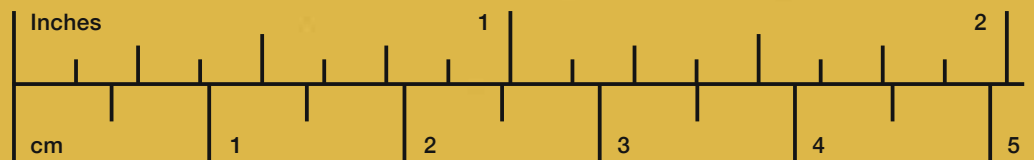
The following articles give a sense (but only a sense; this issue showcases roughly a tenth of our current partnerships) of the breadth and ambition of our work. They reveal a restless University, continuing to redefine what it means to engage with the world. Some articles cover research by Indian nationals who hold appointments in Cambridge, others cover research by those who collaborate with their former students, based in India.

Yes, Cambridge brings approaches, technologies and theories, but we also are in India to learn. As Indian politician Meira Kumar, the first woman speaker of Lok Sabha, once pointed out: “India is a land of diversities, and there lies its strength. Ideas, religions and cultures have been encouraged to interact and create a powerful and unique synthesis, one that believes in the essential oneness of human beings.”

Cambridge is regularly cited in India and the UK as taking a distinctive approach, academically led, institutionally supported and premised on a need to understand what can be done to serve society. We’re there to address challenges in India because the challenges in India are the challenges we face together.

Dr Jennifer Barnes

Pro-Vice-Chancellor for International Strategy





This beautiful illustration of flying birds and sparring goats is more than 400 years old. It's found in an incredibly rare Sanskrit book that is among over 500 South Asian manuscripts which are now available online in the Cambridge Digital Library (<http://cudl.lib.cam.ac.uk>) through the Sanskrit Manuscripts Project (<http://sanskrit.lib.cam.ac.uk>).



Image
Macrophage engulfing a
tuberculosis pathogen

Almost one in four of the world's cases of tuberculosis (TB) are in India and the disease is constantly adapting itself to outwit our medicines. Could the answer lie in targeting not the bacteria but its host, the patient?

Professor Lalita Ramakrishnan is, it's fair to say, a world authority on the biology of TB. She studies the disease – one which most people will know of as a disease of the lungs – using what at first sight seems an unusual model: the zebrafish.

“What most people don't realise is that about 40% of human TB occurs outside the lungs,” explains Ramakrishnan. “It can infect the brain, bone, heart, reproductive organs, skin, even the ear. In fact, TB infection is a basic biology question, and this is the same in zebrafish as it is in humans.”

A whole host of options

“So far, the treatment of TB has focused almost exclusively on using drugs to try to kill the bacteria directly, but there's increasing evidence that there may be benefits to targeting the host”

While treatments do exist, the drug regimen is one of the longest for any curable disease: a patient will typically need to take medication for six months

TB is caused by *Mycobacterium tuberculosis*, which is generally transmitted from person to person through the air. It has been around since at least the Neolithic period, but its prevalence in 19th-century literature led it to be considered something of a 'romantic' disease. The truth is a long way from this portrayal. The disease can cause breathlessness, wasting and eventual death. And while treatments do exist, the drug regimen is one of the longest for any curable disease: a patient will typically need to take medication for six months.

Ramakrishnan is involved in a new trial due to start soon that might allow doctors to reduce the length of this treatment. She is cautiously optimistic that it can be reduced to four months; if successful, however, it may eventually lead to treatments more on a par with standard antibiotic treatments of a couple of weeks.

The trial builds on work in zebrafish carried out by Ramakrishnan and colleagues at the University of Washington, Seattle, before she moved to the Department of Medicine in Cambridge in September 2014. These small fish, which grow to the length of a little finger, helped her and collaborator Professor Paul Edelstein from the University of Pennsylvania (currently on sabbatical in Cambridge) to make an important discovery that could explain why it takes a six-month course of antibiotics to rid the body of the disease (rather than seven to ten days that most infections take) and yet in the lab can easily be killed.

Within our bodies, we have a host of specialist immune cells that fight infection. One of these is the macrophage (Greek for 'big eater'). This cell engulfs the TB bacterium and tries to break it down. This, together with powerful antibiotics, should make eliminating TB from the body a cinch. Ramakrishnan's breakthrough was to show why this wasn't the case: once inside the macrophages, TB switches on pumps, known as 'efflux pumps'. Anything that we throw at it, it just pumps back out again.

"Once we'd identified the pumps, we started to look for drugs that are out there in the market and tested a few of them," she explains. "We found that verapamil, an old drug, made the bacteria susceptible to two of the antibiotics we use to fight TB."

The trial of verapamil, which is commonly used to treat high blood pressure, is due to start soon at the National Institute for Research in Tuberculosis (NIRT) in Chennai, India.

Ramakrishnan is one of a number of brilliant minds working as part of a collaboration between the NIRT and

the University of Cambridge to apply the very latest in scientific thinking and technology to the problem of TB.

An expansion of this collaboration has now become possible through the recent award of a £2 million joint grant from the UK Medical Research Council (MRC) and the Department of Biotechnology (DBT) in India, which will enable the exchange of British and Indian researchers. For Professor Sharon Peacock, the UK lead on the proposal, this means an opportunity to train a new cohort of early-career researchers in an environment where they will have access to outstanding scientific facilities and training, at the same time as becoming familiar with the clinical face and consequences of TB for people in India.

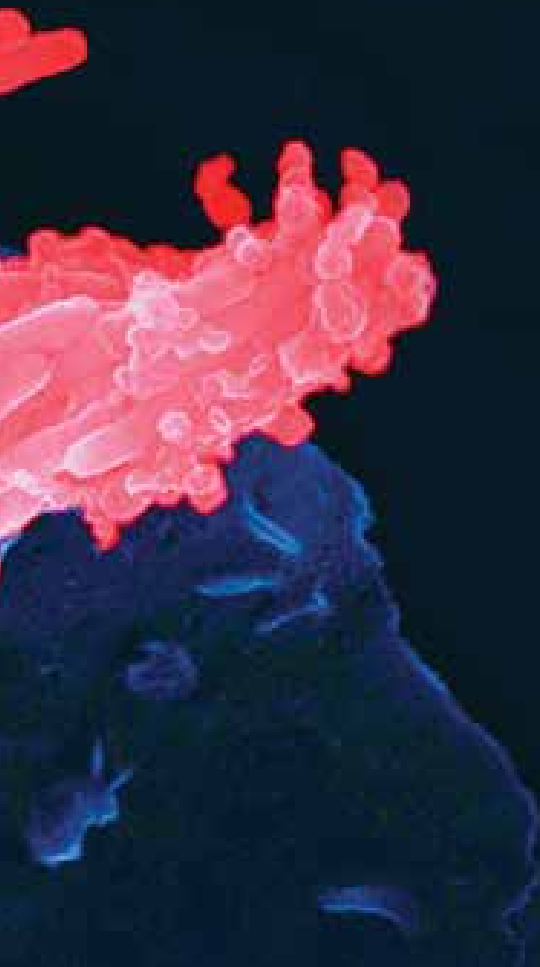
"India is home to a large pool of talented young people with the potential to help fight back against this deadly disease," says Peacock. "Developing a close collaboration between Cambridge and Chennai involving two-way traffic of scientists and ideas is an exciting opportunity to start to tap into this."

There are few places more suitable for the proposed work than India. According to the World Health Organization, India is home to almost one in four of all worldwide cases of TB, with over two million newly diagnosed cases in 2014.

Not only that, but it is one of the countries that has seen an increase in the number of cases of drug resistance to TB – including 'multi-drug'-resistant, and even more worrying, 'extremely' drug-resistant strains of TB against which none of our first- and second-line drug treatments work. In part, this increase reflects improved access to diagnostic services, but the situation highlights why new approaches to tackling the disease are urgently needed, says Professor Soumya Swaminathan, Director of NIRT and the India lead in the collaboration.

"So far, the treatment of TB has focused almost exclusively on using drugs to try to kill the bacteria directly, but there's increasing evidence that there may be benefits to targeting the host. TB is very clever and it manipulates the host immune system to its own advantage, so if we could use drugs to help the immune system, then we may be able to make it more effective."

This is the approach that Professors Ken Smith and Andres Floto from the Department of Medicine at Cambridge, also part of the collaboration, are taking. Smith is looking at the role that specialist immune cells known as T cells play in the persistence of multi-drug-resistant strains of TB. His group has evidence that around two thirds of the population have T cells which have a tendency to become 'exhausted' when activated.



“There is increasing evidence that antibiotic resistance can be predicted from the genome sequence of the organism, and we want to establish and evaluate this technology in India, where it is needed”

“It might be that exhausted T cells can’t fight multi-drug-resistant TB effectively, in which case we need to find a way to overcome this exhaustion and spur the T cells on to rid the body of the disease,” says Smith.

For Floto, the key may lie in the role played by the macrophages and their otherwise voracious appetites. As their Greek name suggests, macrophages ‘eat’ unwanted material (surprisingly similar in action to Pac-Man), effectively chewing it up, breaking it down and spitting it out again.

This process, known as autophagy (‘self-eating’), is a repair mechanism for clearing damaged bits of cells and recycling them for future use, but also works as a defence mechanism against some invading bacteria. So why, when it engulfs TB, does the bacterium manage to avoid being digested?

“Autophagy is partially inhibited by TB itself, but we found that if you overstimulate this mechanism – like flooring the accelerator of a car – you can overcome the bacteria,” explains Floto. “Clearly this will be applicable to normal TB, but we already have drugs that are effective against this. We want to know if this would work against multi-drug-resistant strains.”

Floto and colleagues already have a list of potential drugs that can stimulate autophagy, drugs that have already been licensed and are in use to treat other conditions, such as carbamazepine, which is used to treat epileptic seizures. These drugs are safe to use: the question is, will they work against TB?

“We’ve already shown that carbamazepine stimulates autophagy in cells to kill TB – even multi-drug-resistant TB. We now want to refine it and test it in mice and in fish, alongside a shortlist of around 30 other potential drugs,” he adds.

TB evolves through ‘polymorphisms’ – spontaneous changes in the letters of its DNA to create variants. Because the drug regimen to fight the disease lasts so long, many patients do not take the full course of their medicines. If the TB is allowed to relapse, it can evolve drug resistance.

These patterns of resistance can be detected using genome sequencing – reading the DNA of the bacteria. Peacock believes this technique may be able to help doctors more easily diagnose drug resistance in patients.

“TB is very slow to grow in the laboratory, which means that testing an organism to confirm which antibiotics it is susceptible or resistant to can take several weeks, especially in the case of more resistant strains,” she says. “There is increasing evidence that antibiotic resistance can be predicted from the genome sequence of the organism, and we want to establish and evaluate this technology in India, where it is needed.”

This sequencing data could also then help inform the search for new drugs, explains Professor Sir Tom Blundell from the Department of Biochemistry. He is no stranger to TB: his grandfather died from the disease shortly after the war – though, as Blundell points out, this strain of TB is far less common now, as the organism has evolved in different communities throughout the world.

“We can take the polymorphisms and ask questions such as ‘What does this

mean for the use of current drugs?’” says Blundell. “The nature of the polymorphisms in the TB genome sequence of an infected individual can give us information on where that person was infected and what are the drugs that might be most effective. We can then begin to look at new targets for particular polymorphisms.”

Blundell plans to take the information gathered through the Chennai partnership and feed it into his drug discovery work. He takes a structural approach to solving the problem: look at the shape of the polymorphism and its protein products and try to find small molecules that can attach to and manipulate them. In essence, it’s akin to picking a lock by analysing the shape of its mechanism and trying to identify a key that could turn it, thus opening the door.

Yet even if the Chennai venture is successful, and research from the partnership leads to a revolution in how we understand and treat TB, the team recognise that this is unlikely to be enough to eradicate the disease for good.

“TB is as much a public health issue as one of infectious diseases,” says Ramakrishnan, pointing to Europe, where even before the introduction of antibiotics, the disease was already on the decline. “We need better nutrition, better air, less smoking, reductions in diabetes.”

Swaminathan agrees. “TB is very much associated with poverty and all the risk factors that go with it,” she says. “When people are living in very crowded conditions, when they’re malnourished, TB is going to continue to spread. This is happening in the slums of Mumbai, for example, where we’re seeing a mini-epidemic of multi-drug-resistant TB. Unless we see a rapid improvement in the living standards of people we’re not going to see a very major effect. There’s only so much we can do biomedically.”

I **Professor Lalita Ramakrishnan**
Department of Medicine
lr404@cam.ac.uk

Professor Ken Smith
Department of Medicine
kgcs2@medschl.cam.ac.uk

Professor Andres Floto
Department of Medicine
arf27@cam.ac.uk

Professor Sharon Peacock
Department of Medicine and the
Bloomsbury Research Institute
sjp97@medschl.cam.ac.uk

Professor Sir Tom Blundell
Department of Biochemistry
tom@cryst.bioc.cam.ac.uk

Professor Soumya Swaminathan
National Institute for Research in
Tuberculosis, India
doctorsoumya@yahoo.com

Professor Ashok Venkitaraman
MRC Cancer Unit at Cambridge
arv22@mrc-cu.cam.ac.uk

The next generation

If there's one thing on the side of science v. TB, it's the wealth of talent available in India.

Professor Sir Tom Blundell is quick to praise the Indian postdocs that come to work in his lab. "They tend to be naturally very inquisitive and interactive, with very enquiring minds," he says.

This is something with which Professor Ashok Venkitaraman, Director of the Medical Research Council (MRC) Cancer Unit at Cambridge, wholeheartedly agrees. He has helped establish the Center for Chemical Biology and Therapeutics (CCBT) in Bangalore in part, he says, because "the number of really bright, well-trained young scientists in India is huge. The level of enthusiasm and commitment is something I find quite exceptional."

The CCBT is an inter-institutional centre that links the Institute for Stem Cell Biology and Regenerative Medicine and the National Center for Biological Sciences, both of which are world-class Indian research institutes studying fundamental biology. However, argues Venkitaraman, India needs the capacity to translate fundamental research to clinical application.

It is to help bridge this gap that the CCBT was established, with funding from the Department of Biotechnology (DBT) in India, recently supplemented by a £2 million joint award from the UK MRC and the DBT. The idea is to find innovative ways to discover 'next-generation' medicines against human diseases, by coupling biological research that reveals novel drug targets with approaches in chemistry and structural biology that create potential drug candidates.

Although Venkitaraman's interest is in cancer, he predicts the work of the CCBT will be "disease agnostic", because similar types of novel drug targets have been implicated in infectious diseases, cancer and even developmental defects.

"We desperately need to develop new medicines not just for currently problematic diseases like cancer and TB, but also for the new challenges that are being thrown at us all the time – antibiotic resistance, new infections, metabolic syndromes and diseases of ageing, for example. Nowhere is this need more critical than in emerging nations like India where the spectrum of disease is distinct from countries like the UK."



Image
Macrophage engulfing a tuberculosis pathogen

Education that adds up

“ That number of

250 million

children without basic skills slaps you in the face – you can't ignore it ”



Image
School children in
Ratnagiri, India

We are in the midst of a “global learning crisis” according to UNESCO, with too many children worldwide learning little or nothing at school. A new research programme focusing on India and Pakistan aims to understand what needs to be done to ensure that education adds up.

It’s a numbers game. Three million households, seven million children, 30,000 volunteers, and a decade of assessing the basic reading and maths abilities of 3–16-year olds across India.

This is the size of the largest non-governmental survey of the state of Indian education ever conducted, and it’s a key source of information for communities and policymakers on children’s learning outcomes available in India today. The Annual Status of Education Report (ASER) is all the more impressive given the deceptive simplicity and fundamental importance of the question it seeks to answer: how many children are learning the basics in mathematics and reading?

But the numbers have to be huge given what’s at stake. The education system in India is in crisis; in rural areas, fewer than one in five poor children of around 11 years of age have even the most basic of literacy and numeracy skills, although most have been in school for five years. And it’s a pattern echoed worldwide in what UNESCO has declared “a global learning crisis” – even after going to school, 250 million children globally cannot read, write or count.

“What’s the point in an education if children emerge after years in school without the skills they need?” says Professor Pauline Rose from Cambridge’s Faculty of Education, whose team collaborates with the organisation in India responsible for ASER. “The rhetoric about education used to be about giving children access to school but now it must also be about making sure they learn what they need to learn once they are there.”

Rose was previously Director of UNESCO’s Education for All Global Monitoring Report. In 2014, the Report assembled the first evidence on the scale of the education crisis. “There was already a debate rumbling. It was becoming clear that increasing the number of children enrolling in school was not enough. But the report brought the evidence into one place. That number of 250 million children without basic skills slaps you in the face – you can’t ignore it. It’s also an entry point to understanding why we have got to this situation and what we can do about it.”

Rose leads Cambridge’s Research for Equitable Access and Learning (REAL) Centre, which has highlighted some of the factors that limit children’s learning in India and Pakistan.

Among them are an over-ambitious curriculum that leaves children behind and a lack of training and support for teachers, who may themselves be the product of a poor education.

Now the Centre has been awarded funding by the Department for International Development (DFID) and the Economic and Social Research Council (ESRC) to look at ways to improve the effectiveness of teaching quality in India and Pakistan.

“Education increases opportunities in life, it can pull people out of poverty, with better jobs and higher wages; for girls, education often results in delaying marriage and having fewer children, who as a result are healthier,” she explains. “Nationally, a young, educated workforce can transform the wealth of a country.”

India has made a significant investment in schooling over the past decade, achieving near universal enrolment in primary education. According to government figures, around 195 million children are currently in primary school. However, the question of how effective is the teaching within the classroom has largely been overlooked.

Over the past few months, Rose and Dr Ben Alcott have been using the ASER datasets, covering all of rural India, to identify the extent to which children are learning and who in particular is being left behind.

“Among the most disadvantaged girls, fewer than 10% are learning by the time they should have had five years in school,” says Rose. “Some aren’t learning because they’ve dropped out of school, others because of the poor quality of education. Governments, schools and teachers have tended to focus on the more advantaged, able children. But to close educational inequalities, they must focus on the disadvantaged, whether it’s by poverty, gender, caste or disability.”

Rose and Alcott suggest five key steps: encourage children to start school as young as possible; set the curriculum at the right pace for the majority of learners, not the minority of able learners; train teachers to teach the most disadvantaged learners; provide schools with appropriate textbooks in the right language; and hold schools and policy makers accountable for improving learning outcomes for those who would otherwise be left behind.

Of course, improving the quality of education requires a better

understanding of what is actually going on in the classroom. In the newly funded ESRC–DFID programme, Rose, Professor Anna Vignoles and Dr Nidhi Singal are working with an independent education research group in India – Collaborative Research and Dissemination (CORD) – to create a new dataset that will follow children through their learning experience, from home to school.

Singal’s focus is on children with disabilities: “In many cases, children with disabilities are given access to mainstream school just for ‘socialisation purposes’ – there’s an assumption that they are not there to learn.

“My reason for researching what happens to children with disabilities in school is not only to do with issues around social justice and human rights, but also because problems will be magnified for the most marginalised of the marginalised – if teaching can be more effective for this group then it can respond to the needs of all disadvantaged children.”

The research will assess children both in the household and in schools, testing their basic skills on a yearly basis. The aim is to identify what makes a difference to learning, and to understand the problems teachers face and the support they need.

“There’s a big debate on how the global Sustainable Development Goal of all children learning by 2030 can be achieved,” adds Rose. “This project will help understand what we need to do to make sure we are not failing children who are coming from some of the most disadvantaged of backgrounds.”

Will governments take notice? “I don’t think we as researchers can always go knocking on doors and say look at our evidence. But I do think that, through the networks that CORD and ASER have, this research can have an influence. These partnerships are really central to what we do: it’s no good us sitting here doing all this wonderful research if it’s not actually changing anything for children’s experiences on the ground.”

I **Professor Pauline Rose**
Research for Equitable Access
and Learning Centre,
Faculty of Education
pmr43@cam.ac.uk

Dr Nidhi Singal
Research for Equitable Access
and Learning Centre,
Faculty of Education
sn241@cam.ac.uk

A touch of frugal genius

A “gutsy” Indian approach to innovation is being echoed worldwide by multinational companies adopting “frugal” approaches that help them do business faster, better and cheaper.

Indian languages have no word for innovation. But India has *jugaad*. It means finding practical solutions, being enterprising with resources, and learning from the principles of flexibility and frugality. *Jugaad* is bigger than a word. It’s a mind-set.

To explain, Professor Jaideep Prabhu, co-author of *Frugal Innovation: How to do Better with Less* published in 2015, points to a small clay box in the corner of his office. “It’s an ingenious invention! It consumes no electricity, is 100% biodegradable and produces zero waste.”

The MittiCool fridge is the brainchild of Mansukh Prajapati, a potter by trade. Water in an upper chamber of the clay box seeps through the walls of a lower chamber, cooling it through evaporation. In a country where 500 million people live without reliable electricity, Prajapati realised that his clay fridge could provide huge health benefits by keeping food cool without the need for electricity and at an affordable price; he trained a local workforce and started mass production. *Forbes* magazine has since named him

among the most influential rural Indian entrepreneurs.

“Emerging markets like India, China, Brazil and Kenya are a breeding ground for ideas like the MittiCool that transform scarcity into opportunity and do more with less,” explains Prabhu, the Jawaharlal Nehru Professor of Indian Business at Cambridge Judge Business School.

“*Jugaad* innovation is one reason why, despite a scarcity of food, water and energy, and limited healthcare and education, India has one of the fastest growing economies in the world.”

And now, in a world that is increasingly described as ‘VUCA’ – volatile, uncertain, complex and ambiguous – the ‘winds of frugal innovation are blowing west’, as some of the world’s top companies are embracing business models that look for simple solutions and then deliver them quickly and at less cost.

Prabhu explains that it is a need-based, bottom-up approach to innovation that has largely not been seen in Western economies since the early days of the Industrial Revolution. “The more usual pathway today is to channel innovation through large-scale R&D efforts, often with crippling levels of costs, control and time. Take the pharma industry for example: R&D spending rose from \$15 billion in 1995 to \$45 billion in 2009, yet the number of new drugs launched annually dropped 44%.”



Image

Jugaad: low-cost but high-value solutions



“Any intelligent fool can make things bigger, more complex, and more violent. It takes a touch of genius – and a lot of courage – to move in the opposite direction”

– Albert Einstein

He adds: “*Jugaad* is gutsy and different. It’s rather like comparing the freedom and improvisation of a jazz band with the set of rules and structures followed in a classical piece of music.”

To research the principles of *jugaad*, Prabhu and co-authors Navi Radjou and Simone Ahuja spent four years talking to rural entrepreneurs and leading Indian and Western companies. The result was their 2012 book *Jugaad Innovation* – the first ‘recipe’ for how *jugaad* works and why businesses are adopting its principles in their own innovation programmes.

He gives GE Healthcare as an example. Like other multinationals, GE has set up a large R&D facility in India to tap into India’s massive pool of scientists and engineers at reduced costs. “Although they went there initially for labour arbitrage, what they have stayed for is the potential of the local market, and they are innovating for that market in a *jugaad* way.”

Realising that access to expensive medical devices like electrocardiography (ECG) machines was a problem for many thousands of people in rural areas, they developed a low-cost machine that could be carried by doctors from the city to the countryside. “The innovation,” explains Prabhu, “was in asking what was the ideal product needed for the purpose, and then reusing off-the-shelf components developed for other applications, in this case bus ticket printers and telephone keypads.

“With the *jugaad* approach, instead of doing everything yourself, you look around you and see what’s available and



you combine them – you join the dots.” To date, more than 10,000 of these low-cost ECG units have been sold.

Being able to act flexibly is key, Prabhu explains. “Ratan Tata, Chairman of Tata Group, conceived of the Nano car as an affordable, safe alternative to the perilous two wheelers that often carry whole families in India. When sales flagged, they had to re-think their marketing and customer financing, and even the formality of their rural showrooms.”

His research in the past three years has charted how what has been the norm for Indian innovators is turning into a global trend as companies across sectors – American Express, Ford, Marks & Spencer and Siemens among them – are becoming part of the frugal innovation revolution.

Marks & Spencer, for instance, unveiled its Plan A 2020 last year (“because there is no plan B”), which set out an environmentally frugal business model to reduce waste, increase energy efficiency and source sustainably.

Post economic crisis, Ford has launched innovation initiatives to become more agile in a future crisis. One of these is a partnership with TechShop that offers access to 3D printers and laser and machine tools – a playground for Ford engineers and members of the public to tinker and bring their ideas to life. Within a year, the tinkerers had helped Ford more than double their output of patentable ideas.

But it’s still early days in the revolution. Prabhu and Radjou, co-authors of *Frugal Innovation*, estimate that around 5% of companies in developed economies are advanced in their frugal innovation journey, 15% have adopted some aspects and 80% have yet to formulate a strategy: “Implementing a frugal innovation strategy in any organisation can be daunting. There is no magic formula.” Radjou and Prabhu are not suggesting that traditional innovation pathways involving structured and rigorous R&D should be abandoned. They see each approach as complementary and part of an ‘innovation toolkit’ to be used by businesses in developed and emerging markets alike.

“The developed world needs the liveliness and the growth of the emerging markets,” says Prabhu.

On the other hand, says Tata, “Indian business needs to integrate the structured Western R&D model of innovation with their free-flowing *jugaad* model to create a dynamic balance between both approaches in their organisations.”

Prabhu concludes: “It’s symbiotic – one feeds from the other. *Jugaad* teaches the West to innovate in ways that are different. But equally, emerging markets must learn about what makes the West the West – the technology, the processes.”

“Ultimately, frugal innovation is about people,” says Prabhu. “It is human ingenuity that drives innovation – just like Mansukh Prajapati and his clay fridge – seeking opportunity in adversity, doing more with less, being flexible and simple, and following your heart.”

I **Professor Jaideep Prabhu**
Centre for India and Global Business
Cambridge Judge Business School
j.prabhu@jbs.cam.ac.uk

Man with a Bouquet of Plastic Flowers

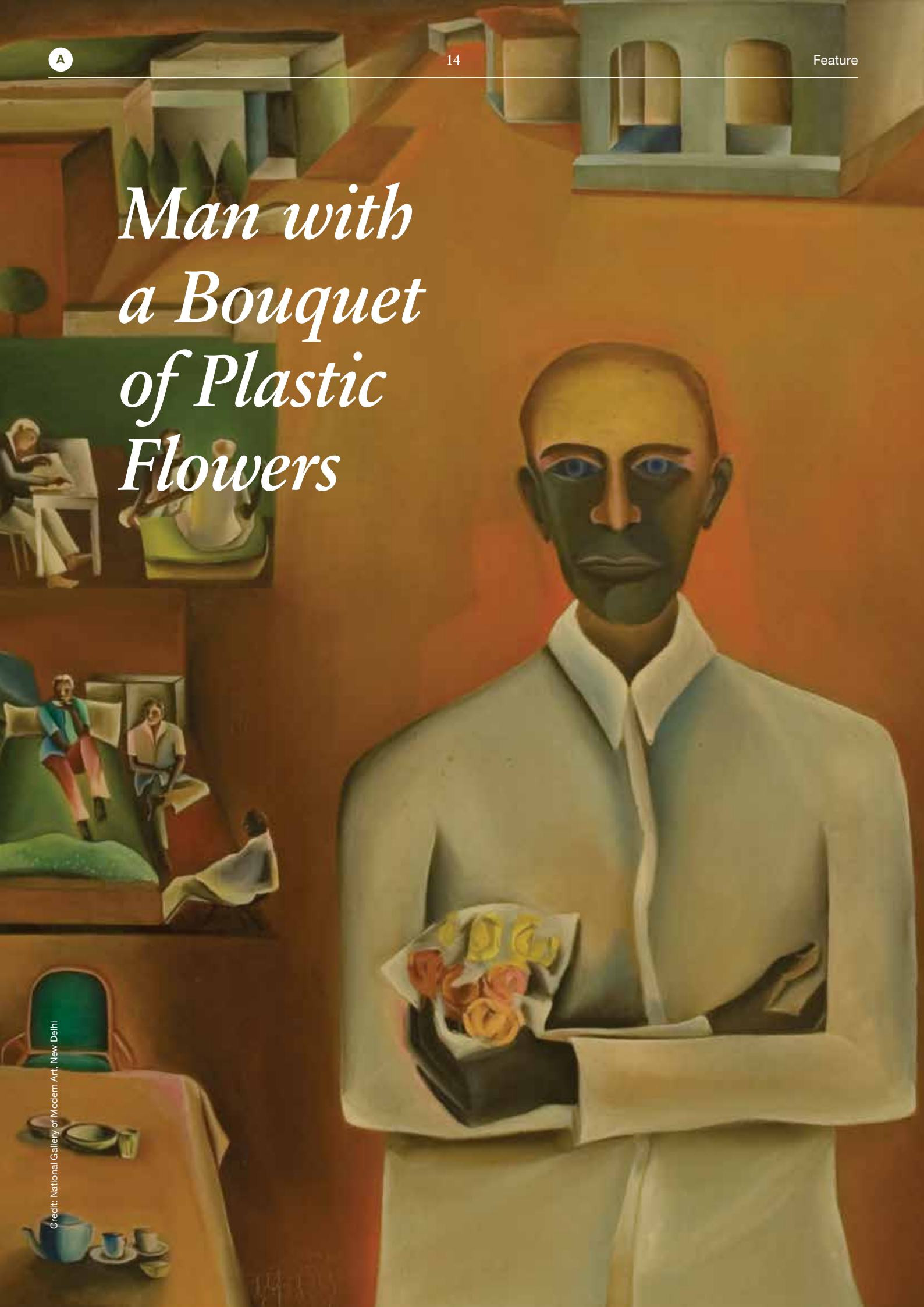




Image
*Man with a Bouquet of Plastic
Flowers* (1976), Bhupen Khakhar

Almost 40 years have passed since Bhupen Khakhar painted one of the most iconic paintings in the history of Indian modern art. Devika Singh offers fresh insights into a generation of Indian artists whose work reflects the politics and social turmoil of a fascinating era.

Bhupen Khakhar's portrait of a man holding a bunch of plastic roses captures a keen sense of solitude. The man at its centre looks straight at the viewer, his face shaded and mouth downcast. His crossed arms contain his emotion; the flowers are clasped tight to his body. The figures and objects that surround him are defined by their separation.

Dr Devika Singh, Smuts Research Fellow at the Centre of South Asian Studies, is a specialist in Indian modern and contemporary art. Her recent research looks at Indian artists who worked post-independence and pays attention to, among others, those (like Khakhar) who attended the art school at the University of Baroda. These artists drew on a range of artistic currents and forged their names on an international stage.

Painted in 1976, Khakhar's *Man with a Bouquet of Plastic Flowers* borrows elements of Indian popular culture. The setting in which Khakhar places his anonymous subject is taken from so-called calendar prints that feature famous politicians with scenes telling their life stories. "Khakhar upends this visual convention," says Singh. "The episodes here speak of domestic intimacy, tension and loneliness."

The 1960s and 1970s marked a critical juncture in Indian art. After the first phase of post-independence nation-building, the country wrestled with the multiple influences that permeated society. As in other post-colonial states, Indian intellectuals began to reflect on the shortcomings of the first generation of Indian political leaders.

The late 1960s saw the emergence of the 'Baroda school', named after the University's Faculty of Arts, where the painter and teacher K.G. Subramanyan had a lasting impact. "Irony and individualism seeped into the work of artists – both are apparent in *Man with a Bouquet of Plastic Flowers*," says Singh.

"The politics of the time had a big impact whether it was the countercultural movements or the anti-Vietnam protests, and also took on specific garbs with the rise of the Maoist rebellion known as the

The man at its centre looks straight at the viewer, his face shaded and mouth downcast

Naxalite movement. In addition, the development of art should also be conceived internationally. Indian artists travelled to the USA, UK and beyond, and Western artists travelled to India. The result was a two-way exchange of ideas."

Khakhar trained as an accountant before finding a voice as a painter. He was particularly attracted to the vitality of 'low art'. At the same time, he was engaged with the 'high art' that was making waves on a global scale. In 1981, he came out as homosexual and, until his death in 2003, his work spoke explicitly of his sexuality.

Singh says: "Khakhar defies the frameworks that art historians and curators like to use. Some commentators have suggested that he's a Pop artist – but he's much more. The strength of his work, and one of the reasons that it remains significant, is that it's disruptive and provokes deep questions about society."

Khakhar's friends and colleagues included artists Vivan Sundaram, Mrinalini Mukherjee and Nalini Malani. Their work addresses matters of political, communal and gender identity, and has been recognised internationally. In spring 2016, Tate Modern will hold a solo exhibition of Bhupen Khakhar's work, and Singh will contribute to its catalogue. Shortly after, she will co-convene a conference at the Paul Mellon Centre for Studies in British Art and Tate Modern, on the history of exhibitions of South Asian art in Britain.

By virtue of her academic studies in Paris (Lycée Condorcet), Cambridge (King's College and Trinity College) and London (Courtauld Institute), and her close connections with India, Singh has met and interviewed many artists and actors of the post-independence art world. In many cases, she has been given access to their archives, art collections and correspondence. Drawing on these experiences, she is writing a book on post-independence Indian art for Reaktion Books and co-curating an exhibition on photography in India for the Media Space in London.

I Dr Devika Singh
Centre of South Asian Studies
ds328@cam.ac.uk



A major research collaboration is looking at how small towns in the hills of India and Nepal are coping with increasing demand for water: who wins and who loses when resources get scarce?

Nainital is picture perfect: lying in a lush green valley in India's 'Lake District', the town sits on a crescent-shaped lake, surrounded by the snow-capped peaks of the Himalayas. Its picturesque location makes it a hugely popular destination for domestic and foreign visitors: each year, Nainital's population increases fivefold due to the influx of tourists, placing huge strains on the town's resources, including the water supply.

It's not just tourists that are contributing to the strain, however. For years, Nainital has been plagued by illegal construction, which has been affecting its ability to supply water. The main lake in Nainital is connected to a smaller lake via an underground channel, and together they supply most of the town's water. The smaller lake remains dry for just over half the year, but when it fills again during the monsoon, it becomes an important reserve reservoir for the main lake.

But despite a ruling from the Indian government banning development in the dry lake bed and the surrounding area, illegal construction has been relentless, to the point where the smaller lake can no longer store enough water to supply the main lake, and water levels in Nainital are under severe pressure.

"Not being able to supply water is a major liability for any government or local authority," says Dr Bhaskar Vira of Cambridge's Department of Geography.

"What we've been doing is looking at the underpinning science, seeing what the political and social issues might be, and then working with the relevant people who can intervene and make a difference."

Vira is leading a major research project that is examining the ways in which small towns in hill and mountain regions of South Asia depend on springs, streams and rivers for their supply of water. Vira and his colleagues from the Southasia Institute of Advanced Studies in Nepal and the Centre for Ecology Development and Research (CEDAR) in India are looking at six towns – four in India (including Nainital) and two in Nepal – to understand how they are coping with the ever-increasing demand for water. The project is part of the Ecosystem Services for Poverty Alleviation programme, which is funded by the Natural Environment Research Council, the Economic and Social Research Council and the UK's Department for International Development.

India is a wet country, but almost all of the rain falls in about two and a half months during the annual monsoon. The problem in India is how to safely store and transport water so that it's available 12 months a year, and distributed evenly throughout the country.

Small towns – those with populations below 100,000 – in the hill regions of India and Nepal have grown rapidly, with very little planning for infrastructure needs, more generally, and water supply, in particular. Across the region, almost half of the urban population in the Indian states of Himachal Pradesh and Uttarakhand, and in the hill regions of Nepal, live in small towns.

“There are always going to be winners and losers when it comes to water in India”

"Many of these towns are looking at what you'd call nature-based solutions – they don't have the budget to pump water in from 200 miles away," says Vira, who is working with Dr Eszter Kovacs on the project. "So they're much more dependent on the water that's available in their immediate vicinity, and they're looking at ways they can harness the resources they do have."

One of the approaches that the researchers are taking is to identify and protect what they call 'critical water zones' – places where the springs that ultimately supply many of these towns are recharged. For example, one of the towns (Rajgarh, in Himachal Pradesh) which the researchers are studying has its water source in the Churdhar Wildlife Sanctuary, which not only protects the wildlife, but also protects the water supply, as the trees absorb the water so it doesn't run off. The ultimate benefit is a dual one, since the landscape is protected, but so is the water supply for the town.

"Water is a precious resource, and it's very rare to find a water source in India that has no other existing users," says Vira. "So there are always going to be trade-offs; there are always going to be winners and losers when it comes to water in India." In Rajgarh, water that is being piped from 14 km away to the town is

Not a drop to drink!



Image

Nainital, northern India, faces an ever-increasing demand for water

bypassing villages along the way, raising concerns about the water needs of the surrounding rural communities.

In Mussoorie, another popular Uttarakhand tourist town, the team is looking at the *dhobi* (washing) community, which for about 100 years has washed all of the laundry generated by the local hotels, schools and passing tourists by hand in the local stream. Today, the work of the *dhobi* is supplemented by washing machines and driers, but much of the washing is still done in the stream, and many people still rely on it for their livelihoods.

About 15 years ago, town authorities needed to increase their water capacity and approached the *dhobi* community to 'share' their water with the town, through the laying of new pipes and construction of a pumping station. Unsurprisingly, they were resistant to the idea. "Eventually, a compromise was reached so that some of the water was left behind for the *dhobi* to continue washing, but is it working? Was it a fair trade-off, for the town or the *dhobi*? These are the kinds of issues we're looking at," says Vira, who is Director of the University of Cambridge Conservation Research Institute.

Back in Nainital, the researchers supported local activists who brought a case to the Uttarakhand high court to remove the illegal buildings. The Cambridge-CEDAR team also convened expert geologists and hydrologists who made recommendations about how the lake's water-storing capacity could be restored, which in turn supported the legal case.

"Additionally, through our awareness campaign, we were able to galvanise the local population so they could see the risk that this illegal construction is posing to



Credit: Ross Hugggett on Flickr

the community," says Dr Vishal Singh from CEDAR, one of Vira's collaborators, who recently spent two months in Cambridge on a Commonwealth Professional Fellowship. "This lake is so important for the region's sustainability and, for years, construction was allowed to continue despite the fact that it was illegal."

In mid-July, the high court ordered the formation of two committees: one to mark and demolish the illegal constructions, and another to determine which officials were liable for allowing the construction to happen in the first place.

Singh, who grew up in Nainital, says he'd like to see the dry lake bed returned to what it was when he was a child. "It should be cleaned up and preserved so children can play there in the dry season," he says. "This lake is so important to Nainital's identity – let's preserve it."



Dr Bhaskar Vira

Department of Geography
and University of Cambridge
Conservation Research Institute
bhaskar.vira@geog.cam.ac.uk

Dr Eszter Kovacs

Department of Geography

Dr Vishal Singh

Centre for Ecology Development
and Research, India



KEEPING THE SUPPLY CHAIN FLOWING



Image
Increasing the efficiency of food supply chains can decrease wastage

In this age of rapid and escalating change, what can businesses do to flourish? Take a look at their supply chains, say researchers in the Centre for International Manufacturing, based on their research in the UK and India.

A typical supply chain can be a vast, sprawling network of producers, suppliers, 'super middlemen', retailers and consumers that connect, for instance, a piece of mined aluminium with a finished car, or a field of wheat with a loaf of bread on the table.

Dr Jag Srai and the team he heads in the Centre for International Manufacturing like nothing better than a complex, multi-faceted supply chain, because within the connections lies a vital source

of competitive advantage. Companies that can more optimally 'configure' this complex network have the opportunity not only to improve their business but also to do so sustainably in an otherwise resource-hungry and wasteful world.

"Many supply chains today have developed over time, a consequence of often short-term tactical decisions or ill-considered mergers and acquisitions," he explains. "There may be large distances between component supply and the end product, delays in sharing information along the chain, or an excessive fragmentation of activities.

"Within little more than a generation, the traditional model of a vertically integrated firm, which has most of its component and final product in-house, has become fragmented.

The project is funded by the UK's Engineering and Physical Sciences Research Council and the Indian Department of Science and Technology. It began a year ago but follows a previous study in which the team created a set of representations of the UK food supply chain for dairy, fruit and vegetables, and staple foods. It was painstakingly collated from industrial reports, literature reviews and first-hand case studies, as well as interviews with key industrial players.

The resulting map provides a fascinating insight into the dynamics of networks that many consumers are unaware of – such as the one that links a cow on a dairy farm to a pint of milk on a UK doorstep (a seven-step process, as it turns out).

Crucially, it also identifies how new trends are being driven by an increasing demand from consumers to know where their food is coming from and for cheaper, own-brand labels. "Organisations that are able to align these complex networks with their own strategic aims have an opportunity to set themselves apart from their competitors," explains Srail.

One of the researchers' main interests is how maps such as this can be used to foster a more sustainable approach to manufacturing, as Dr Mukesh Kumar explains: "Food security, for instance, is a global challenge as populations continue to grow, yet 30–40% of food in the UK is currently wasted, mostly at the retail and consumer end of the chain."

Working with their collaborators in India, the team has now generated comparable maps of the Indian food supply chain. The comparison could help each to explore the key differences and identify how multinationals from one country looking to do business in the other might need to adapt a supply chain to work best.

"The UK food retail chain is dominated by a few large, organised retailers who control 73% of UK grocery sales, and as a result exert considerable influence over upstream partners in the chain, whereas in India this type of organised retail accounts for only 12% of sales," Kumar explains.

"But the largest difference is where the wastage happens. In India, most wastage occurs at the early stages of the supply chain, with tonnes of fruit and vegetables perishing due to poor handling and storage facilities and lack of cold chain infrastructure."

According to estimates by the United Nation's Food and Agriculture Organization, each year about 40% of India's fresh fruit and vegetables rot before reaching consumers' plates, as does an amount of wheat almost equal to Australia's total annual production.

"Supply chains that link the UK and India incur waste up- and downstream. The figures are quite scary – you sometimes wonder how anything ends up on a plate!" observes Srail.

He highlights how crucial it has been to work closely with Indian researchers, industry and policy makers, helped by funding through the UK India Education and Research Initiative: "We have chosen partners in India who complement our skills. It's like a supply chain in action! It has seen a continuous stream of collaborations emerging out of this, none of which would have been possible without this project."

For instance, researchers at the Indian Institute of Technology Ropar and the Indian Institute of Management Lucknow have been looking at how simulation and modelling of operations could be used to flag up sustainability challenges.

"Our Centre's research on 'network mapping' tools and close links to industry have meant that we have provided methods and industry contacts to our partners, while leveraging their specialist skills in the specific areas that we require. We have also taken the combined output to inform our wider work in the University's Strategic Research Initiative on Global Food Security," says Srail.

"Technology, supply chains and the way markets and regions develop become interesting change agents. I believe that our research network will be able to anticipate these changes," he adds.

"It's only by understanding a company's overall global supply network – a 'whole system' approach – that it's possible to appreciate the opportunities and the benefits that can emerge for doing things better, wherever you are in the world."

Today, for manufacturing a typical consumer electronics product, dozens of firms in as many countries might be involved in its manufacture, with activities dispersed among narrowly focused companies distributed across developed and emerging economies."

Srail's team has been mapping these global networks across multiple sectors, developing novel tools for their visualisation and for identifying opportunities to reconfigure them to meet demand more effectively.

Of particular focus has been a comparison of the food and pharmaceutical process industries, and the assembly power houses of aeronautical and automotive industries, in both the UK and India.

"Manufacturing is a top priority in both countries," explains Professor Sir Mike Gregory, former Head of the Institute for Manufacturing, where the Centre is based. "In the UK, the government has placed manufacturing at the heart of plans for economic recovery. And in India, the government launched the 'Make in India' initiative in 2014 with the aim of transforming the country into a major global manufacturing hub and generating millions of new jobs."



Dr Jagjit Singh Srail
Dr Mukesh Kumar
Professor Sir Mike Gregory
 Centre for International
 Manufacturing,
 Institute for Manufacturing
jss46@cam.ac.uk

Cambridge's engagement with India

The University's strategic engagement with India focuses on collaborative research partnerships across a wide range of disciplines; including public health and biomedical sciences; energy and sustainability; education, humanities and social sciences; and innovation, entrepreneurship and business.

Science and Technology

- JAMMU
- Seismic structure modelling •
- CHANDIGARH
- Drug discovery
- Supply chains
- DELHI
- Gas turbine performance
- Public health training
- Organic–inorganic devices •
- Split-site PhD programme with nano-doctoral training centre •
- LUCKNOW
- Drug discovery
- Supply chains
- Coronary thrombosis
- SIKKIM STATE
- Seismic monitoring
- KANPUR
- Fluid dynamics
- Solar cells
- GWALIOR
- Supply chains
- SHILLONG
- Seismic monitoring
- JAMSHEDPUR
- Microstructural properties of materials
- Transformation of steel
- KOLKATA
- Detection of pesticides •
- Steel composites
- Drug discovery
- Seismic velocity •
- NAGPUR
- Sunspot behaviour
- Fuel cells

- MUMBAI
- Geotechnical centrifuge development
- Nanoscience and nanotech
- Thorium as uranium replacement
- PUNE
- Drug discovery
- Radio astrophysics
- HYDERABAD
- Gas turbine performance
- Solar cells
- Microstructural properties
- Genotype mapping •
- Gas sensing platform •
- Fuel cells
- GULBARGA
- Public health monitoring •
- MANGALORE
- Conservation studies
- BANGALORE
- Advanced materials
- EU–India grid infrastructure
- Multiple carrier generation •
- Solar cells
- Solar atmosphere
- Design education
- Conservation studies
- Avian flight mechanisms
- Stem cells
- Drug discovery
- Signalling and development
- Centre for Chemical Biology and Therapeutics
- Open source drug discovery
- Infection and immunity
- Student Conference on Conservation Science
- Digital social healthcare •
- CHENNAI
- Paleo-climatological environments
- Tuberculosis immunity and infection
- Diabetes epidemiology
- Oncology
- VELLORE
- Community participation to tackle tuberculosis
- Tuberculosis immunity and infection
- MYSORE
- Drug discovery
- COIMBATORE
- Wild rice improvements

Arts, Humanities and Social Sciences

- DELHI
- Historian exchange programme
- Political economy and development
- Visual histories of South Asia
- Sanskrit manuscripts
- Migration patterns
- Religious organisations as service providers
- Global histories of science
- Climate change and Indus Valley Civilisation •
- Ethnographic analysis of police union politics
- South Asia democratic cultures

- GAZIABAD
- Unique identity project
- JAIPUR
- Sanskrit manuscripts
- South Asia democratic cultures
- LUCKNOW
- Climate change and Indus Valley Civilisation
- JODHPUR
- Sanskrit manuscripts
- VARANASI
- Land, water, and settlement
- Sanskrit manuscripts
- AHMEDABAD
- Sustainable housing
- Teacher training
- KOLKATA
- Migration patterns
- MUMBAI
- Kāśikāvṛtti Sanskrit research
- Economic history and growth
- ICT in reducing rural development bottlenecks
- BANGALORE
- Education policy formations
- Education of disabled children
- Visual histories of South Asia
- CHENNAI
- ICT in reducing rural development bottlenecks •
- PONDICHERRY
- Sanskrit manuscripts

Business entrepreneurship and other related activity

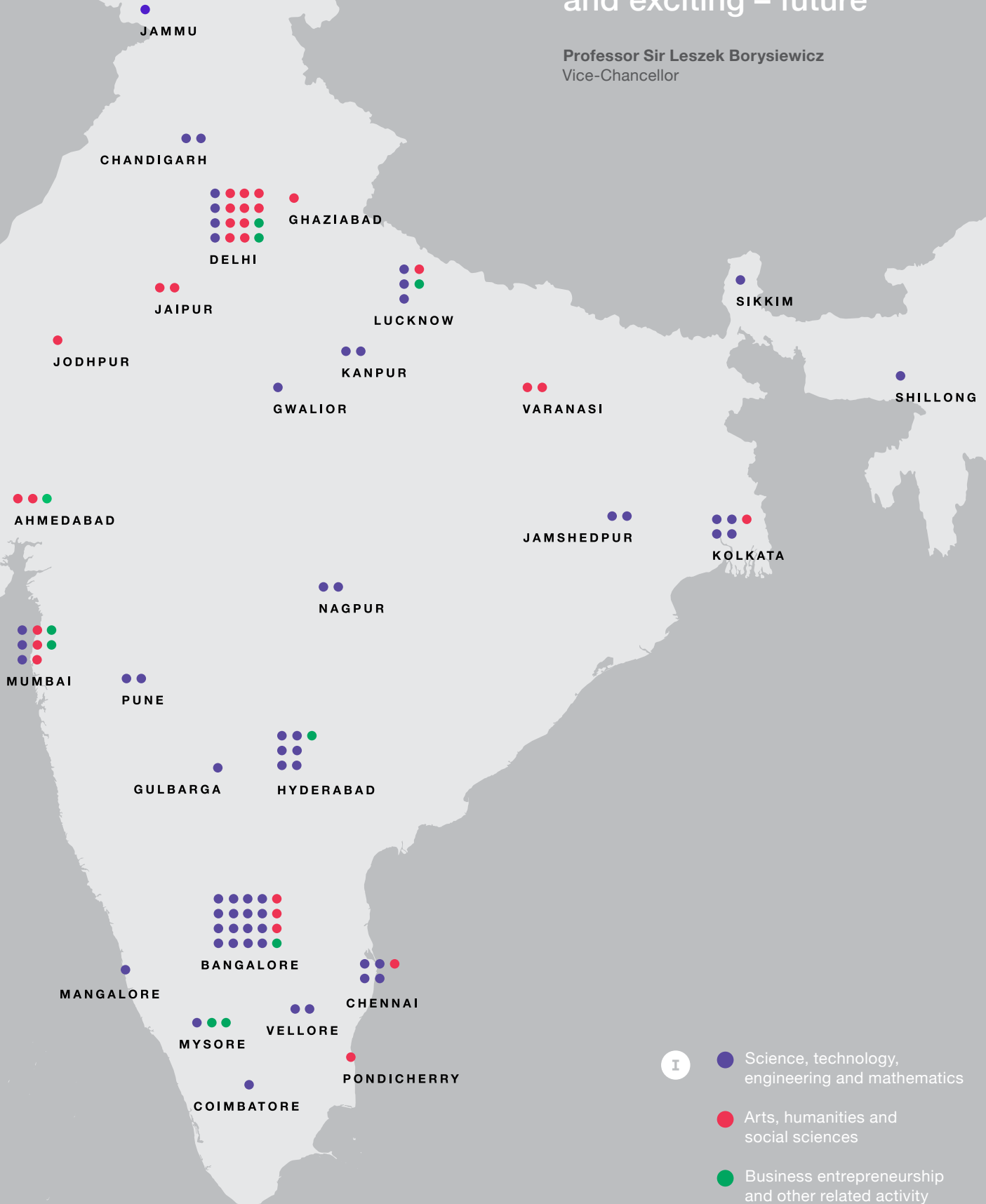
- DELHI
- Entrepreneurship training
- Training for Indian Administrative Service officers
- LUCKNOW
- Development programmes
- AHMEDABAD
- Family entrepreneurship training
- MUMBAI
- Sustainability leadership
- Strategic road-mapping
- HYDERABAD
- Training for police officers
- BANGALORE
- Bangalore–Cambridge Innovation Network
- MYSORE
- Capacity building
- Indian corporate governance



• Funded by the UK–India Education and Research Initiative (UKIERI)

“Our relationship with India recognises our shared past and a rapidly developing – and exciting – future”

Professor Sir Leszek Borysiewicz
Vice-Chancellor



A cacophony of more than a billion voices and stories all straining to make themselves heard. Some shout, some whisper, others scream. Few are silent



A DEMOCRATIC CACOPHONY

India is home to one of the most vibrant, engaged and mystifying democracies on the planet.

Cambridge academics, across a wide range of disciplines, are working on the ground – with citizens, charities, NGOs, fellow scholars and politicians – to try to untangle it.

In a remote village in a forgotten corner of West Bengal lives an old man called Fakhruddin Gazi. He has lived in the village for every one of his long years. However, since India was partitioned in 1947, Fakhruddin Gazi has lived in fear, unable to leave the small landholding his family has owned for generations.

A thousand miles away in Rajasthan, the state's first female Chief Minister is showered with garlands and the kind of affection usually reserved for pop stars, not politicians. The masses clamour to touch her feet. Devotees deify her with all the reverence of a Hindu goddess.

Just down the road in Jaipur, an enterprising and popular middle-aged man is making and receiving calls on one of his three mobile phones. The conversations he conducts link voters to politicians, slum-dwellers to local officials. If you need a fake birth certificate, a government job, or your home connected to the electrical grid – his is the number you need to call.

In Gujarat, a casually employed labourer is being interviewed. The man is a Dalit, a member of the lowest caste in India's order of social stratification. Dalits used to go by another name – 'untouchables'. He tells Dr Manali Desai, who has travelled from Cambridge to interview him, about his political leanings.

"Since the BJP came there have been no more riots. We live peacefully. It is not as it used to be. There is progress everywhere. It has become America now... nice cinemas and long roads have been built. It all seems like a dream."

This is India on any given day. A cacophony of more than a billion voices and stories all straining to make themselves heard. Some shout, some whisper, others scream. Few are silent. Each and every voice – Brahmin or Dalit, Muslim or Hindu, old or young – has something unique to tell us about the nature of democracy in India: its flaws and foibles, its puzzles and paradoxes, its successes and its shames. All have their part to play in informing our understanding of the world's largest democracy; a democracy often celebrated, regularly condemned and impossible to ignore.



Image
Election campaign in the 2014
General Election in India



Credit: Nilanjana Chowdhury/Al Jazeera on Flickr



Image

A woman shows her inked thumb as proof of voting

Some of the stories Cambridge academics are uncovering – like Professor Joya Chatterji's experiences with Fakhruddin Gazi – interrogate the foundations and principles of post-partition democracy, highlighting a legacy of injustice and inequality against a sub-class of India's own citizens. The work of others, like social anthropologist Dr Anastasia Piliavsky, directly challenges the Western world's accepted notions of what democracy should look like, arguing that our rush to brand Indian politics as a basket case of corruption and crime is, in part, a failure in our own understanding as to the needs and sensibilities of more than 800 million registered voters in India.

Chatterji's work on refugees, minorities and the rights of marginalised groups in West Bengal and beyond raises questions about the history and meaning of citizenship for minority communities in India, particularly for individuals like Fakhruddin – an Indian Muslim caught on the 'wrong side' at the time of partition.

Once the head of a Sunni family that owned several acres of good paddy land and many heads of cattle, Fakhruddin

has lived with the consequences of partition since the late 1940s. In the upheaval that came with the new international border and the Radcliffe Line, his family fled to East Pakistan (now Bangladesh) while he stayed to tend to the graves of his ancestors.

Gangs grabbed most of his property and burned his home while the police did nothing. In 1965, India enacted 'enemy property' ordinances that gave the state unfettered powers – which could not be challenged in any court – to seize the property of anyone 'fraternising with the enemy'. Since then, Fakhruddin has been afraid to leave the tiny plot he still has, for fear of being dispossessed.

"My work looks at the origins and precise nature of minority citizenship," says Chatterji, Director of the Centre of South Asian Studies. "Unless you understand its legacies of impoverishment, deprivation and seizure of property, addressing contemporary problems of minorities in India's democracy will be less straightforward."

"Minority citizens are seen as 'lesser' and this is enshrined in the constitution. Even when India and Pakistan accorded these citizens formal membership, they set them apart legally from full citizenship in vital ways. Their standing is diminished."

Chatterji has made extensive use of records kept in the National Archives of India, and many regional archives across the subcontinent, to supplement extensive fieldwork and oral history. Despite the current status quo and unwillingness

of governments to tackle the issues surrounding minority citizenship, Chatterji does have hope for the future.

"There is much that is great about Indian democracy and much that is not. My work on internally displaced Muslims has persuaded me that the impact of partition on minorities who stayed behind was far less benign than has often been assumed. However, I do see lots of light in popular organisation and mobilisation around a host of issues of injustice in India. We don't see this emanating from the state or high politics, but the country is absolutely teeming with everyday movements on the ground. The state has to pay attention to them. There are protests all the time; we have an Arab Spring of sorts in India every day."

Sociologist Dr Manali Desai is another researcher with an ambivalent view on India's future. Her recent work has looked into the reshaping of the country's political landscape and how the ruling BJP party (historically seen as conservative and elitist) has won the significant backing of many lower-caste voters in states like Gujarat.

While the rise, and aspirational voting habits, of the Indian middle class has been much discussed and documented, Desai believes that the BJP's paradoxical success in attracting voters from the Dalit and Other Backward Classes (OBCs) – when the personal benefits of voting BJP cannot be demonstrated – has a great deal more to tell us about 21st-century India.

"The BJP claims that the people of Gujarat support [Prime Minister] Narendra Modi because of the development he has brought to the state," says Desai. "Yet numerous studies show that social development in Gujarat lags behind that of many states and the benefits of development have not reached beyond the middle classes."

Desai believes that it is precisely the BJP's 'development discourse' that has attracted lower-caste votes in high numbers despite many Dalits and OBCs continuing to face widespread discrimination, lacking access to water and electricity supplies, and being subject to evictions and relocations. 'Development' and 'peace' were words often uttered in interviews, something the BJP juxtaposed with an 'unruly and chaotic' past.


"India is still in the early stages of exploding capitalism, and for hundreds of millions of India's young, this is all they have ever known," says Desai. "Urban voters are not aware of rural issues and young rural men seek to migrate to cities to find jobs. This has all helped the BJP's remarkable rise as India has repositioned itself in the global economy."

Looking to the future, Desai says: "I am both hopeful and not. The established order of things was stultifying the economy and politics, and new technology and innovation, an increasingly young population and a new awareness of India's place globally are all very positive developments.

"But there has also been a deepening and normalising of Hinduistic strains. This is particularly potent when young people should be opening up, not closing down. That worries me. India has very deep inequalities around caste. When not addressed, they come back with a vengeance. But overall, yes, India will become a more democratic place. Lower-caste parties rule in several states despite being excluded in more and more ways. More quotas and more jobs for lower castes is the only way around this."

India's democracy is a subject of consuming fascination to Anastasia Piliavsky, who in 2013 went on the

A democracy often celebrated, regularly condemned and impossible to ignore



campaign trail with Rajasthan's future Chief Minister Vasundhara Raje. She was given privileged access to Raje's campaign machine and the chance to understand what Piliavsky calls "the logic of Indian democracy" – an oxymoron to many.

Politics and corruption in the world's largest democracy are never far from the headlines, either in Indian newspapers or on news websites around the world. A Google search for 'Indian corruption' returns almost as many hits as 'Indian democracy'.

Piliavsky's research occupies the liminal area between the two as she seeks to understand why a political system so often regarded as corrupt and amoral continually engages hundreds of millions of voters – and attracts turnouts which are the envy of many Western democracies.

Piliavsky believes that looking at India solely through the prism of Western sensibilities misses the moral significance of 'relationships' and 'community' that

underpins all Indian politics – subjects that Desai also came across regularly in her interviews with Dalits and OBCs.

"In India, politics is about relations and hierarchies," says Piliavsky. "It is about obligations and loyalties to one's own. We may call this irruption into the bureaucratic process and law 'corruption'. Yet it is precisely this 'corruption' – the sprawling, tangled web of human relations – that animates India's democratic process and drives hundreds of millions to the voting booths."

She contends that attachments to people, rather than 'left' or 'right', is what draws many into political life and shapes political loyalties. Voters expect politicians to give, be it food, money or public goods, as part of their responsibility to the voters. Many do not see the distribution of food and alcohol as corruption. To them, the betrayal of relations is the real meaning of corruption; when people don't deliver to those whom they owe.

Getting anything done in India – from buying a car, arranging a marriage or attracting voters – requires 'approaches'. Cash does pass hands, but there are few quick and easy sales. Each arrangement works through bonds of mutual sympathy, favour and trust. Few in politics can avoid spending large sums of money on their constituencies.

As well as defending a democracy often compared with the scandalised governments of Sub-Saharan Africa, Piliavsky is also more sanguine than many Western commentators about Modi's Prime Ministership.

"Most of those who voted for Modi did so because they believe him to be a highly effective leader, a man who can get things done. However sound that belief may be, delivering on his many (often improbable) promises is what will keep him in office – not backing a violent ideology rejected by many Indian citizens and the international community alike. Having promised millions of new jobs and having brought many Muslims to the BJP, Modi can now ill afford communal riots.

What India has shown is that no politician is ever good enough. No one can sit pretty, Modi least of all. He's going to have to work day and night to deliver a small portion of what he's promised. The Indian citizens are not fools, they know he promised too much, and they will watch him closely. There is no cult of personality, only a 'cult of action'. And if Modi's electorate does not feel he has done enough by the end of his first term in office, they will expunge him, just as they did with Indira Gandhi before. This is the way of India's restive, fickle democracy."

Nehru and Today's India

To complement the work of Cambridge researchers studying Indian democracy, the University is also active as a neutral and respected convenor of debates in India among Indian politicians, writers, artists, economists and diplomats.

Following the success of the inaugural India–Cambridge summit in 2012, the Vice-Chancellor's Endowment Fund supported a major conference in Delhi in February 2015 on 'Nehru and Today's India', which was broadcast on NDTV, one of India's leading news channels.

Both events were conceptualised by Dr Shruti Kapila (Faculty of History), who also provided Indian election analysis for Al Jazeera and Bloomberg TV, and has inaugurated a seminar series on Indian issues in the House of Lords.

I **Dr Manali Desai**
Department of Sociology
md644@cam.ac.uk

Professor Joya Chatterji
Centre of South Asian Studies
jc280@cam.ac.uk

Dr Anastasia Piliavsky
Department of Social Anthropology
an379@cam.ac.uk

Dr Shruti Kapila
Faculty of History
sk555@cam.ac.uk

The Alpine–Himalayan belt, which stretches from the Mediterranean to the Pacific, is one of the world’s most seismically active regions.

Now, a combination of earth science, social science and education is being used to help the region become more resilient to earthquakes, protecting lives and property.

The Ganges is India’s most iconic river, flowing from the Himalaya to the Bay of Bengal, and its massive river basin is one of the most fertile and densely populated regions in the world. The Ganges flows through 29 cities with a population over 100,000, 23 cities with a population between 50,000 and 100,000, and close to 50 towns.

But someday – perhaps tomorrow or perhaps in 100 years – a massive earthquake will hit the region, and the consequences could be catastrophic: as many as a million lives in the Ganges river basin could be at risk, primarily because buildings have not been constructed to be earthquake resilient, despite the fact that the relevant building codes are in place.

Of course, earthquakes don’t respect borders, and India is not alone in being at risk due to poorly constructed buildings. Northern India lies in the Alpine–Himalayan earthquake belt, which stretches from the Mediterranean to the Pacific. It is the second-most seismically active region in the world, and responsible for around 20% of the world’s largest earthquakes. The belt is being created by ongoing plate tectonics: as the African, Arabian and Indian plates continue to move northwards, they collide with the Eurasian plate.

The earthquake belt includes the most famous of the great trade routes, the Silk Road, which follows the edges of deserts and mountains, and high plateaus like Tibet. The landscape of the Silk Road has been shaped by

Earthquakes without frontiers

earthquakes over millions of years: forcing mountains upwards and making life in the desert possible by controlling where water comes to the surface.

As the earthquake faults grind rocks together they make an impermeable clay, which often forces water to the surface along spring lines, determining where people live. To the casual observer, it seems as if the major earthquakes in this part of the world often seem to ‘target’ towns and cities but, in reality, people are often simply living where the water is, which is also where earthquakes happen.

Between 2 and 2.5 million people have died in earthquakes since 1900. Approximately two thirds of those deaths occurred in earthquakes in the continental interiors – places like northern India. Over that time, advances in the scientific understanding of earthquakes have been translated into impressive resilience in places where the hazard is well understood, which are mainly on the edges of the oceans. Comparable advances have not, however, taken place in most parts of the continental interiors, where the hazard is still much less well identified and poorly understood.

“Earthquake science has progressed so that we’re now much better at recognising the signals in the landscape that tell us whether a particular place is dangerous,” says Professor James Jackson, Head of Cambridge’s Department of Earth Sciences. “We can’t tell you exactly when an earthquake is going to happen, but we can say it will happen, not least because it’s happened before. If it’s happened before, it will happen again. What we can do, however, is to understand earthquakes better and use that knowledge to help make buildings safer.”

Between 2 and 2.5 million people have died in earthquakes since 1900. Approximately two thirds of those deaths occurred in earthquakes in the continental interiors – places like northern India





Four years ago, with funding from the Natural Environment Research Council, Jackson and colleagues from other universities in the UK established Earthquakes Without Frontiers (EWF), an international partnership bringing together earthquake scientists from across the great earthquake belt, from China to Italy, in order to share expertise. “But it soon became clear that the project was about much more than earthquake science, and the real issue was how to translate science into effective policy, which requires an understanding of the social context in which people live,” says Jackson.

With additional funding from the Economic and Social Research Council, EWF expanded to include social science and policy dimensions. The project, which runs until 2017, has three overarching objectives: to increase knowledge of earthquake hazards across the region; to establish greater resiliency against these hazards; and to establish a well-networked interdisciplinary partnership to support local earthquake scientists. Within Asia, there are more than 50 national level stakeholders who are working with EWF on earthquake risk reduction.

Across much of the earthquake belt, people live in large cities, mostly in poorly built apartment blocks and buildings that have not been designed to withstand earthquakes. Large cities such as Tehran, Almaty and Bishkek have all been destroyed multiple times by earthquakes, and it’s only a matter of time before the next one hits. The problem that EWF faces is convincing the public and policy makers of the importance of making towns and cities more earthquake resilient.

“There are going to be around a billion new homes built across Asia over the next 10 years – let’s build them so they are safe”

“In these big cities, everyday life is difficult enough: they’re very congested, they have huge problems with traffic, air quality, water quality, food supply and poverty,” explains Jackson. “And quite understandably, the risk of an earthquake seems quite remote compared to daily worries. But that doesn’t make the threat go away.”

“We face two main problems: the first is that there is a lack of awareness of the fact that seismologists cannot predict earthquakes – it’s just not something we are able to do or will be able to do,” says Dr Supriyo Mitra of the Indian Institute of Science Education and Research Kolkata. Mitra obtained his PhD at Cambridge, and is now one of the key Indian academic collaborators on the project, primarily working in Indian-administered Kashmir. “The other problem is that there is a lot of resistance to making buildings safe. It is an additional cost, but it’s a necessity and we need to get that across to people.”

Perhaps the most important change that can be made to increase earthquake resilience in these areas is the enforcement of building codes. The building codes in Los Angeles and Tehran are similar, but the difference is that in Los Angeles, most buildings are constructed according to those codes, while in Tehran most are not, so as a result, Los Angeles is highly resilient to earthquakes, while Tehran remains very vulnerable.

“Enforcement comes not just from legal enforcement, but education,” adds Jackson. “People are really starting to realise that this is important. And once you educate the public, it rises up the agenda because the public insists that it does.”

“There are going to be around a billion new homes built across Asia over the next 10 years – let’s build them so they are safe.”



Professor James Jackson
Department of Earth Sciences
jaj2@cam.ac.uk

Dr Supriyo Mitra
Indian Institute of Science Education
and Research Kolkata, India

The history of science has been centred for too long on the West, say Simon Schaffer and Sujit Sivasundaram. It's time to think global.

The year was 1789; the place Bengal. Isaac Newton's masterpiece *Principia Mathematica* was being translated for only the third time in its already 100-year-old history; this time, into Arabic.

The author of this remarkable feat of scholarship was Tafazzul Husain Khan. According to a member of the ruling East India Company: "Khan... by translating the works of the immortal Newton, has conducted those imbued with Arabick literature to the fountain of all physical and astronomical knowledge."

For Professor Simon Schaffer, who has researched the story of Tafazzul's achievements, the complex work of translation is deeply significant. Tafazzul worked with scholars in English, Persian, Arabic and Sanskrit language communities in his efforts to connect Newtonian theories with the Indo-Persian intellectual tradition. For Tafazzul was, as Schaffer describes, "a go-between".

"The 'go-betweens' are the individuals who, across the centuries, have been the cogs that have kept science moving," he explains. "They are the knowledge brokers and translators, networkers and messengers – the original 'knowledge transfer facilitators'. Their role may have disappeared from mainstream histories of science, but their tradecraft has been indispensable to the globalisation of science."

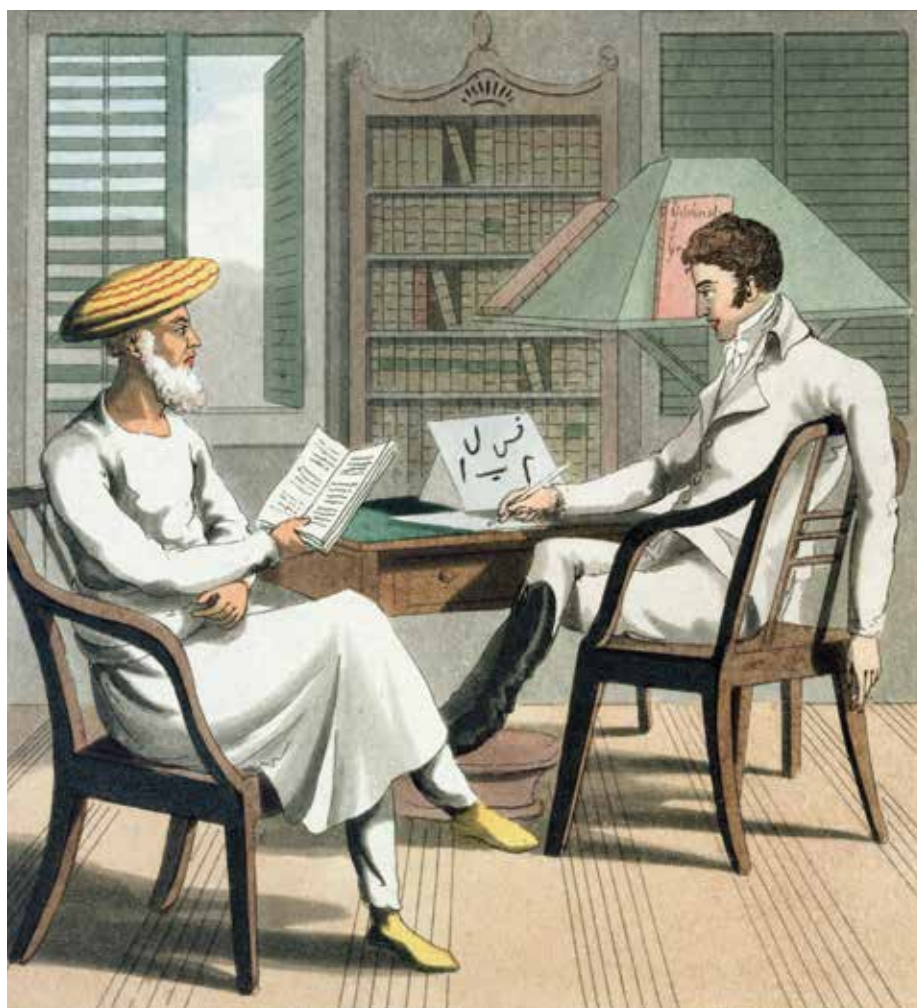
Schaffer and Dr Sujit Sivasundaram are historians of science with an interest in understanding how the seeds of scientific knowledge have spread and grown. They believe that the global history of science is really the history of shifts and reinventions of a variety of ways of doing science across the world.

They, and others, have called for a retelling of science's past, not only to be more "culturally symmetric" but also because the issue has enormous contemporary relevance.

"A standard tale is that modern science spread around the world from Western Europe, starting about 500 years ago based on the work of those such as

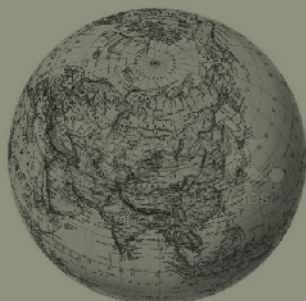
*Europeans often
accumulated
knowledge in India
by engaging
with pandits, or
learned men*

A WORLD OF SCIENCE



Image

The European in India, 1813
by Charles D'Oyly (1781–1845)



Newton, Copernicus and Galileo, and then Darwin, Einstein, and so on,” explains Schaffer. “But this narrative about the globalisation of science just doesn’t work at all. It ignores a remarkable process of knowledge exchange that happened between the East and West for centuries.”

“Successful science is seen to be universal in its applicability,” adds Sivasundaram. “Yet, accounts of scientific discovery, heroism and priority have been part and parcel of a political narrative of competitive ownership by empires, nations and civilisations. To tease this story apart, we focus on the exchanges and ‘silencings’ across political configurations that are central to the rise of science on the global stage.”

Over the past two years, with funding from the Arts and Humanities Research Council, he and Schaffer have undertaken a programme of debates to ask whether a transregional rather than a Eurocentric history of science could now be told.

To do so, they teamed up with researchers in India and Africa, including Professor Irfan Habib from Delhi’s National University of Educational Planning and Administration and Professor Dhruv Raina of Jawarhalal Nehru University, and in December 2014 held an international workshop at the Nehru Memorial Library in New Delhi. “And now our debate is also being carried forward by a new generation of early-career researchers who came to the workshop,” adds Sivasundaram.

One conundrum the researchers debated was how global narratives of science could have been missed by scholars for so long. It largely stems from the use of source materials says Schaffer: “It’s an archival problem: as far as the production and preservation of sources is concerned, those connected with Europe far outweigh those from other parts of the world.”

“If we are to de-centre from Europe, we need to use radically new kinds of sources – monuments, sailing charts, courtly narratives, and so on,” explains Sivasundaram. He gives an example of Sri Lankan palm-leaf manuscripts: “The *Mahavamsa* is a Buddhist chronicle of the history of Sri Lanka spanning 25 centuries. Among the deeds of the last kings of Kandy, I noticed seemingly inconsequential references to temple gardens. This led me back to the colonial archive documenting the creation of a botanic garden in 1821, and I realised that the British had ‘recycled’ a Kandyan tradition of gardening, by building their colonial garden on the site of a temple garden.”

Moreover, says Sivasundaram, the mechanisms of knowledge assimilation are often overlooked. Europeans often accumulated knowledge in India by engaging with pandits, or learned men. “The Europeans did not have a monopoly over the combination of science and empire – the pioneering work of Chris Bayly [see panel] shows how they fought to take over information networks and scientific patronage systems that were already in place. For Europeans to practice astronomy in India, for instance, it meant translating Sanskrit texts and engaging with pandits.”

“Very often, scientific achievement is used as a standard to measure a country’s progress because science and technology can intervene in problems of hunger, disease and development,” adds Sivasundaram. “If a biased history of science is told, then the past can become what Irfan Habib has called a ‘battlefield’, instead of a ‘springboard’ for future research or indeed for conversation across cultures.”

This is why, says Schaffer, it becomes so important to provide a better account of the worldly interaction between the kinds of knowledge communicated, the agents of communication – like Tafazzul Husain Khan – and the paths they travelled.

I **Professor Simon Schaffer**
Department of the History
and Philosophy of Science
sjs16@cam.ac.uk

Dr Sujit Sivasundaram
Department of History
sps20@cam.ac.uk

The art of listening in

Knowledge networks were as important to the building of British political intelligence in north India in the 18th and 19th centuries as they were to the diffusion of science.

No discussion of Indian history, or of the communication and the movement of knowledge, would be complete without reference to the work of the late Professor Sir Christopher Bayly (1945–2015).

Bayly saw the role of Indian spies, runners and knowledgeable secretaries as crucial to the British in helping to keep information and gossip flowing in the 1780s and 1860s. His groundbreaking research uncovered the social and intellectual origins of these informants, and showed how networks of ‘go-betweens’ helped the British understand India’s politics, economic activities and culture.

“One overriding reason why the East India Company was able to conquer India... was that the British had learnt the art of listening in on the internal communications of Indian polity and society,” he explained in his seminal work *Empire and Information* (1996).

Ultimately, however, India’s complex systems of debate and communication challenged the political and intellectual dominance of the British; it was their misunderstanding of the subtleties of Indian politics and values, he argues, that contributed to the British failure to anticipate the 1857 Mutiny–Rebellion.

World-renowned for his enormous contributions to his subject, Bayly was the Director of Cambridge’s Centre of South Asian Studies until his retirement in 2014, as well as President of St Catharine’s College, and the Vere Harmsworth Professor of Imperial and Naval History in the Faculty of History.

He completely transformed people’s understanding of India in the 18th and 19th centuries, explains Professor Joya Chatterji, the Centre’s current Director: “Chris has been one of the most influential figures in the field of modern Indian history. Every one of his monographs broke new ground, whether in political, social and economic, or latterly intellectual history.”

His work was increasingly drawn towards ‘world historical’ comparisons and connections; his *The Birth of the Modern World* (2004) transformed the understanding of the history of modernity itself, drawing attention to its richly complex, overlapping global roots.

12/04/15
Physical activity helps to maintain normal blood sugar and blood pressure.

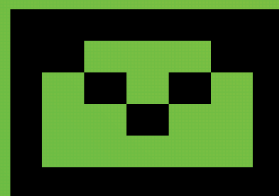
20/04/15
Active life makes you live longer.

21/04/15
Take fruits as a whole and not as a juice.

01/05/15
Desk-bound job? Take short walk to relax your body and mind.

09/06/15
Get off the bus one or two stops ahead and walk to the destination.

Phone for a doctor



Worried you might be at risk from diabetes? Check your phone: it might help stop you getting the disease. And if you already have diabetes? Your phone might even help you monitor your condition at home.

It's the middle of the afternoon. You hear the trill of an incoming text message on your phone. You pick it up, expecting it to be from a friend.

Skipping breakfast will make you overeat at lunch.

Ah yes, this must be from Professor Ambady Ramachandran. You've never met him and he doesn't know you personally, but he has sent you this helpful reminder because you are one of over 20 million Indians at a high risk of developing type 2 diabetes. Tomorrow, you tell yourself, you will make sure you eat before going to work.

"It seems paradoxical that something as simple as text messaging could help prevent you from developing diabetes," says Professor Nick Wareham, Director of the Medical Research Council (MRC) Epidemiology Unit at the University of Cambridge. And yet, the evidence suggests it might work.

In 2013, Ramachandran, who founded and runs a diabetes hospital in Chennai, India, and is President of the India Diabetes Research Foundation, reported the results of a study that found almost a third fewer men in the high risk group went on to develop diabetes if they received between two and four texts a week giving advice on diet and exercise.

"This is a big – and surprising – effect," says Wareham. And India, as with many other countries worldwide, needs something big (and, possibly, surprising) to help it tackle the growing burden of diabetes and obesity. Recent estimates suggest there are 68 million people living with diabetes in India, the majority with type 2 diabetes. A mixture of poor diet and lack of exercise, low birth weight followed by rapid growth, and genetic predisposition – Indians tend to develop diabetes at a lower body-mass index than Caucasians – means that diabetes is twice as common in India as it is in the UK.

While targeted strategies aimed at high risk individuals are likely to be effective, there is no way they could be rolled out to 20 million people, says Wareham. "If you had to individually counsel that many people, it would be unaffordable. Simple, pragmatic, scalable approaches are the only ones that are feasible."

Ramachandran's study involved a relatively small sample, but such was its promise that he and Wareham have teamed up to see whether text messaging might be scaled up to a larger population,

with support from the MRC and the Indian Council for Medical Research. An additional arm of the study, being carried out by Imperial College London, is looking at whether the same concept would work in the UK.

Wareham and colleagues use a combination of a risk score that they have developed, which looks at factors such as age, sex and weight, and a simple blood test to identify people at risk of developing diabetes: these are the individuals who are targeted by the text messages.

It is the pervasiveness of mobile phones that could make this scheme work: there are almost a billion mobile phones in India – the country ranks second only to China. Smartphones are still much less common, with just around one in six people in the country owning one, but this is expected to increase significantly, potentially making India the second largest market worldwide.

If, as expected, smartphones really do take off, they could hold the answer to helping those people unfortunate enough to develop diabetes to monitor their condition, says Chris Lowe, Emeritus Professor of Biotechnology at the Department of Chemical Engineering and Biotechnology in Cambridge.

“We’re interested in developing diagnostics that are appropriate for taking measurements at home or in the doctor’s surgery, without the need for a specialist,” says Lowe. For over a decade, he has been looking at making ‘smart’ holograms that are sensitive to chemicals or biological compounds.

Unlike conventional holograms, which are two-dimensional, Lowe’s holograms are three-dimensional, created by shining a one-nanosecond laser pulse into a gel, suspended in which are silver nanoparticles. The silver nanoparticles arrange themselves into planes, giving the hologram a particular colour. But when glucose – from a blood or urine sample – comes into contact with the hologram, it binds to sensors within the gel, known as receptors, causing the hologram to expand or contract; the planes move closer together or further apart and the light given off by the hologram changes colour, moving towards the blue or red end of the spectrum.

“You can see these changes visually, but to increase the accuracy you need to be able to quantify the change, and this is where smartphones come in,” he says. Using the phone’s camera and a downloadable app, it could be possible to give an accurate measurement of the level of glucose in the body. His colleague Dr Gita Khalili Moghaddam is working on software that would enable the app to operate in a real-world setting,

17/06/15
Moderate physical activity keeps you healthy.

30/06/15
Fruits are delicious and nutritious, include them as part of your diet.

compensating for variability between phones and the environment.

The technology works in a similar way to QR codes – the black-and-white square patterns which, when scanned on a phone, redirect you to information online. In fact, says Moghaddam, the holograms could themselves be QR codes. “You can save the patient’s information in the holographic QR code, so when you scan it and send off your glucose levels, embedded in this are your own details,” she says.

Lowe and colleague are exploring ways of delivering the holograms, from strips of holograms through to contact lenses that measure glucose in tear fluid as a surrogate for blood sugar levels, and even to having holograms that can be tattooed onto skin. These could even do away with the need to take regular blood finger-prick tests.

Despite the hi-tech nature of this technology, part of its beauty lies in its cost. The holograms could be mass-produced at a very low cost – even if there were embedded into daily-use contact lenses, the cost would be negligible, making them particularly attractive in the developing world. At the moment, patients need special instruments to monitor their glucose levels – in areas such as rural India, these are often given away, but their cost then has to be incorporated into the disposable strips used by the instruments.

“With smart holograms, there is no instrument,” says Lowe. “It’s just your smartphone. And soon, almost everyone will have one of those.”

I **Professor Nick Wareham**
MRC Epidemiology Unit
nick.wareham@mrc-epid.cam.ac.uk

Professor Chris Lowe
Department of Chemical Engineering and Biotechnology
cl1@cam.ac.uk

Dr Gita Khalili Moghaddam
Department of Chemical Engineering and Biotechnology
gk320@cam.ac.uk



Spiritual violence and
the divine revolution of

Sri Aurobindo Ghosh

New research on the early writings of one of India's most famous spiritual leaders is revealing how he fused Hindu theology with anti-imperialist politics and philosophy to create an archetype of the 'spiritual revolutionary' that still haunts modern India.

In 1879, a young Indian boy arrived in England from Calcutta (now Kolkata), in the state of Bengal, sent by his father to receive a British education. Aurobindo Ghosh showed enormous promise and would go on to receive a scholarship to study classics at King's College, Cambridge.

By the time he had moved back to Calcutta in 1906, the state had been split in half by Lord Curzon, Viceroy of India. The British claimed this schism was 'administrative', but it was largely an attempt to quell burgeoning political dissent in the region.

The partitioning of Bengal – a prime example of British 'divide and rule' policy – incensed many sections of the population, and the Indian 'middle classes' mobilised under the banner of Swadeshi, the anti-imperial resistance movement that would eventually force the British to revoke the partition six years later.

While 'moderate' Indian leaders lobbied the British for greater representation, many of the younger generation in Bengal – particularly Hindus – believed that 'prayer, petition and protest' would fail, and more radical action was needed: non-cooperation, law-breaking and even violence, in the name of 'Swaraj' – self-rule. One of the figureheads of 'extremist' Swadeshi was Aurobindo, a teacher, poet, polemical journalist and underground revolutionary leader.

In his later years, Aurobindo became one of India's most influential international Gurus, redefining Hinduism for the modern age with his experimental mysticism (Integral Yoga), global outlook and life-affirming metaphysics of divine evolution. His philosophy is taught across India and was recognised early on by prominent Western figures including Aldous Huxley, who nominated him for a Nobel Peace Prize in 1950. He was also a major inspiration for the 'New Age' movement that swept across the West.

Today, the popular perception of Aurobindo's life is divided. The early political firebrand and later mystic are seen as separate identities, split by a year of imprisonment during which Aurobindo was spiritually 'awakened'.

However, for Alex Wolfers, a researcher at Cambridge's Faculty of Divinity, this dichotomy is a false one. The spiritual and political blurred throughout Aurobindo's extraordinary life, particularly during his time as a leading light of radical Swadeshi, says Wolfers, who is investigating spirituality in Aurobindo's early political writing.

Through research at archives in Delhi, Kolkata and Aurobindo's Ashram in Pondicherry, Wolfers has traced the emergence of a new theology of revolution

in Aurobindo's thoughts, one that harnessed the spiritual to challenge "the sordid interests of British capital".

Aurobindo fused the political and spiritual, mixing ideas from European philosophy, particularly Hegel and Nietzsche, with Hindu theology under the aegis of the Tantric mother goddess, Kali, and Bengali Shaktism – the worship of latent creative energy – to develop a radical political discourse of embodied spirituality, heroic sacrifice and transformative violence.

He complemented this with poetic interpretations of the French revolution and Ireland's growing Celtic anti-imperialism, as well as contemporary upheavals in Russia, South Africa and Japan.

Through his polemical speeches and essays, Aurobindo furiously developed his political theology against a backdrop of assassination, robbery and bombings, weaving all of these strands into what Wolfers argues is the central symbolic archetype in his political theology: the 'revolutionary Sannyasi'.

In Hindu philosophy, Sannyasis are religious ascetics – holy men who renounce society and worldly desires for an itinerant life of internal reflection and sacrifice. Throughout the late 18th century in famine-stricken Bengal, roving bands of Sannyasis – together with their Muslim counterparts, Fakirs – challenged the oppressive tax regime of the British, and repeatedly incited the starving peasants to rebel.

Aurobindo amplified and weaponised this already potent symbolic figure by recasting him as a channel for divine violence. By embodying Swaraj, the revolutionary Sannyasi could kill with sanctity. Violent revolution became spiritually transcendent, without murderous stain.

"Just as the traditional Sannyasi intensifies his inner divinity through ascetic practice or the voluntary embrace of suffering, Aurobindo venerates the element of violence and adversity in existence as a prelude to collective 'self-overcoming'," says Wolfers.

As Wolfers puts it, the revolutionary Sannyasi is the man of spirit and action, sanctified by sacrifice, whose volatile potency is ready to detonate like a bomb in a violent spectacle of Liebestod: the 'love-death' of German romanticism, the ecstatic destruction needed for rebirth. As Aurobindo himself states, "war is the law of creation".

"This violent vanguardism is often seen as an infantile politics that limits broader participation in a political movement," says Wolfers, "but even the non-violent Gandhi significantly borrowed from Aurobindo's transgressive politics. This form of terrorism was crucial in implanting

the radical ideals of Swaraj that later anti-imperialist politics were structured around."

Aurobindo's highly Anglicised, elite Cambridge education had left him estranged from his roots. On his return to India in 1893, he had to 're-learn his identity' through classical Hindu texts, whereas his younger brother Barin, who had grown up closer to home, was more familiar with the living traditions of Bengal.

Together, Aurobindo, the prophetic visionary, and Barin, the untiring activist, organised the spread of a loose network of underground terrorist cells throughout the land and incited the increasingly politicised student communities of Bengal to submit themselves to the militant spirituality of the 'revolutionary Sannyasi'.

"These young revolutionaries took their cues from Aurobindo's discourses of Sannyasi renunciation: they left their families and society, living rigorously according to rituals and timetables, dressing in the traditional ochre robes of the Sannyasi. Some even made use of Tantric practices, carrying out blood rites and secret vows in cremation grounds to purify their life in contact with death," says Wolfers. "Through these practices they cast off their allocated 'middle classness', breaking free from imposed British society."

The revolutionaries targeted figures of British state authority and, in May 1908, Aurobindo was arrested in connection with the botched assassination attempt of a notorious magistrate. It was while in solitary confinement in Alipore jail that he experienced the 'spiritual awakening' that confirmed his mystic status.

Over 60 years after his death in 1950, Aurobindo's legacy continues to live on, despite often being misappropriated for political gain.

"The figure of the 'revolutionary Sannyasi' has had an enormous afterlife: in its various guises and mutations, its influence is evident across the political spectrum from Gandhian mobilisation to Bengali Marxism and Hindu nationalism. Even today, it remains an important trope in Indian politics," says Wolfers.

"From as early as the 1920s, Hindu nationalist organisations began to recast Aurobindo in an increasingly right-wing mould to assert Hindu dominance against the subcontinent's Muslim and Christian minorities," he says. "But hyper-masculine Hindu chauvinism, still a major force in Indian politics today, stands in sharp contrast with his original inclusive and 'anarchic' outlook."

I Alex Wolfers
Faculty of Divinity
aw435@cam.ac.uk

Mirage maker

In a small room in the Physics Department is a machine that's helping researchers in India and the UK develop the next generation of solar materials. It makes mirages.

Aditya Sadhanala wanders over to the wall, turns a pulley, and a wooden box about a metre squared swings up and away. Below it gleams an array of carefully positioned lasers, deflectors and sensors surrounding a piece of glass no bigger than a contact lens. He flips a switch and creates a 'mirage'.

This is a photothermal deflection spectrometer (PDS) and the mirage – only the width of a human hair in distance from the glass – is helping researchers to measure the quality of materials that turn light energy into electricity.

"We can see one defect in a million molecules," explains Sadhanala, who built the machine while working on his PhD in the lab of Professor Sir Richard Friend. "The PDS technique measures the amount of light absorbed by a material with up to five orders of magnitude more sensitivity than conventional techniques, making it one of the most sensitive absorption spectrometers in the world."

A mirage is formed as light is bent when it passes through a medium with varying refractive index – a puddle of water seems to appear on the road ahead, for instance, when light meets hotter air radiating from the ground on a sunny day.

Sadhanala's machine creates a mirage effect when light absorbed by the solar material is released as heat, which passes to a liquid that surrounds the sample. When a laser beam is directed to pass parallel to it, the mirage deflects the beam; the amount of deflection corresponds to the amount of heat absorbed, which in turn corresponds to the amount of light absorbed.

"Before, we would have had to make a whole solar device and spend months and months testing it to find out how efficient the material is," explains Sadhanala. "Now you can measure a new material in half a day, and you don't even need to make the whole device – you just need to be able to coat the material onto glass and make a mirage."

5th

India is the fifth largest producer and consumer of electricity

A few weeks ago, Tushita Mukhopadhyay – a chemist at the Indian Institute of Science, Bangalore – carefully packaged up five new materials and flew to the UK to test them on the ‘mirage machine’ in Cambridge, and analyse other properties with researchers at Imperial College London. She had spent months making and characterising the materials – all of them belonging to a group of organic solar cells (OSCs) that can be printed as thin-film sheets.

India faces a huge energy challenge to meet the current government’s mission of ‘Power for all, 24x7, by 2019’

What connects the two researchers, and indeed many other chemists, physicists and engineers, is the APEX project – an ambitious Anglo-Indian initiative to turn fundamental advances in solar materials into commercial reality.

APEX involves research institutes in Bangalore, Delhi, Hyderabad, Kanpur and Pune in India, and Brunel (which leads the partnership), Cambridge, Edinburgh, Imperial, Swansea and Oxford in the UK, plus solar industries in both countries. It has received almost £6 million funding since 2010 from the Indian Department of Science and Technology and Research Councils UK.

“Solar has always been the eventual solution to our energy problems but it’s always been the day after tomorrow,” explains Friend, who leads the Cambridge component. “Each of the partners in this project has an extensive research programme aimed at developing highly efficient photovoltaic devices, but there is a disconnect between what you can do in the lab and what can be rolled out at huge scale. This project is aimed at moving from established science to a viable technology.”

First though, there is the matter of achieving a major cost reduction and efficiency increase in solar power. The APEX team started by focusing on developing a new class of ‘excitonic’ solar cell (which produces electricity from the sun’s energy through the creation of an ‘exciton’ – essentially a free electron). Instead of using the conventional solar material, silicon, the researchers used solar materials made from organic dyes – dye-sensitised solar cells (DSSCs) – which are easy to make, easy to process and cost less.

However, one of the main issues surrounding the search for alternative solar materials to silicon has been their power conversion efficiencies (PCEs) – the amount of the sun’s energy that can be trapped and turned into electricity.

The PCE for silicon is around 25%, whereas the current state-of-the-art PCE figures for DSSCs and OSCs are a little over 10%. To achieve incremental boosts in these figures, researchers like those in Friend’s group have been analysing what happens at the nanoscale when light hits the material. For instance, they now know that manipulating the ‘spin’ of electrons in solar cells can dramatically improve their performance.

Mukhopadhyay, who travelled to the UK thanks to funding through the UK-India Education and Research Initiative, explains: “My materials have a fast charge transport rate – as we’ve now proved at Cambridge and Imperial – but they have a low PCE. We think that a process called singlet fission, in which one exciton splits into two, is happening. This makes them interesting to look at because if more than one charge carrier is generated then this can increase the PCE.”

70%

of electricity production is based on coal

Another family of materials the team has high hopes for is a set of perovskite-structure lead halides. Work at the University of Oxford has already achieved a PCE of above 17% for such materials, and Sadhanala has begun using his machine to see the effect of different processing methods on their properties.

As well as developing cheap, high-performing solar materials, the team will scale up towards prototypes that replicate the performance achieved in the research phase.

“India may well leapfrog the UK in taking up radical new approaches to power generation”

Although the aim is to provide a technology that can reduce the carbon footprint of electricity generation anywhere in the world, solar energy could fulfil a massive demand for energy in India. India is the fifth largest producer and consumer of electricity, around 70% of which is based on coal, yet around 200 million people are without access to electricity. With a rapidly growing economy and more than 1 billion people, India faces a huge energy challenge to meet the current government’s mission of ‘Power for all, 24x7, by 2019’.

200m

are without access to electricity

In fact, India could be an ideal place to adopt new solar technologies on a large scale, says Friend: “India is already currently running the largest renewable capacity expansion programme in the world, and there is a sense that the next technology revolutions may well happen in an emerging country like India that hasn’t already built its future renewables-heavy electricity system.”

“India may well leapfrog the UK in taking up radical new approaches to power generation,” he adds. “We want APEX to contribute to the search for such approaches now and in the future. This is a journey, not a day’s outing.”



Aditya Sadhanala
Department of Physics
as2233@cam.ac.uk

Professor Sir Richard Friend
Department of Physics
rhf10@cam.ac.uk

Tushita Mukhopadhyay
Indian Institute of Science,
Bangalore
tushita_chemistry@sscu.iisc.ernet.in



Things The sad sailor and *The Sea-Pie*



Images
Whitehouse's portrait, diary and map



Film available
<http://bit.ly/1WnnZpc>



The idiosyncratic diaries of one man's voyage from Liverpool to India, and the souvenirs he bought there, have found their way into the archives at the Centre of South Asian Studies.

A woman peeks from the curtain of a wagon, rich men parade on a bejewelled elephant and a pensive scholar clutches the tools of his trade: these paintings, no bigger than playing cards, adorn transparent sheets of mica.

They were painted in India for the colonial tourist trade, and are so rare and fragile that Dr Kevin Greenbank, Archivist at the Centre of South Asian Studies, where they are held, admits: "I get the shakes when I handle these."

"They represent an important period in Indian art – the Company School of painting – when Indian art developed perspective," he adds. "But what I especially like about them is they accompany a pair of diaries written by a sailor, Charles Augustus Whitehouse, who bought them when he sailed to India on the *Brig Medina* in 1842."

Unlike many diaries that have become a source of historical information, Whitehouse's are a deeply personal and highly idiosyncratic account – so much so that they were often written as if there was no-one else on board.

Entitled *The Sea-Pie*, the diaries were inscribed to his mother, and come with a caveat scrawled across the front: "Here it comes something hot from the oven. Mind your eye or it may burn your fingers."

Alongside his self-portrait, seascapes, a map of his route and a smattering of voyage details – "Potato cakes for tea" – Whitehouse expresses a sudden descent into melancholia, for his sweetheart back home has left him for another. The sad tale, replete with bereft poetry, takes up a third of one diary until, rallying, he finishes: "So after moping for a good half an hour I went below for a cigar."

The Centre of South Asian Studies archive comprises a unique collection of photos, papers, films and oral histories covering many aspects of life in South Asia.

www.s-asian.cam.ac.uk/archive/archome



Extreme sleepover: The mystery of a damp bed and other tales

Credit: All images, Girija Godbole



Girija Godbole travels to a remote village in western India to understand the effects of the increasing incidence of land sale on a rural society, and makes the acquaintance of a naughty goat.

As I drive with Parubai to meet the rest of her family in Pune district, I spot in my rear mirror a motorbike following us. I slow down, wondering if it is someone I know. The rider, a man in his mid-30s, signals for me to wait. It's already close to sunset and Parubai, who is assisting me with my doctoral fieldwork, is a bit nervous as this area is not considered to be the safest, especially for two women on their own.

"Madam, are you looking to buy some land? I can show you a plot, *road-touch, clear title*. Many city people like you have bought land from me," he assures me in his salesman's patter. I am amused – till recently, this region was seen as the back of beyond, but now with the real-estate boom, one can see vast stretches of land marked off with barbed wire fences. Through my research with Dr Bhaskar Vira in the

Department of Geography, I am trying to understand the impact of this increasing incidence of land sale on a rural society.

When we reach the village, I am surprised to see several expensive cars standing in front of a modern house where one of my other helpers' hut once stood. I see his wife Alka making rice *bhakari* – a kind of flatbread – on a traditional wood stove in a small kitchen at the back. She invites me to have a bite.

As I sit with smoke making my eyes water, she gives me updates. Her husband, who belongs to the dominant Maratha caste, has sold large chunks of family land and used the money to buy a car, build this house and organise a lavish marriage ceremony for their daughter. Tonight he is hosting a party for a local politician.

"Money so earned finds a hundred ways to disappear," says Alka despairingly. During my stay in the villages, I have often heard similar comments. With the escalating land prices, the notion of land as a symbol of status and marker of identity is beginning to change. Disputes over land ownership and increasing

The notion of land as a symbol of status and marker of identity is beginning to change

disparity among the villagers due to the influx of money through land sale are affecting the social networks adversely.

We retire to Parubai's house. It's a total contrast, with its mud walls and tiled roof with gaping holes covered by a plastic sheet. Unlike Alka, she is a landless *Katkari*, one of the most socio-economically marginalised tribes in India. Her husband herds a few goats to earn a living. It is an open secret that she brews liquor for extra cash.

After a meal of rice and spicy potato curry, I struggle to write my field notes by a small kerosene lamp – there is no electricity in the house – while Manjula, Parubai's granddaughter, spreads a few sheets on the mud floor for the four of us to sleep on.

Hens kept under a basket in the corner rustle. A drunkard turns up asking for booze. Highly embarrassed, Parubai somehow sends him away. It is getting chilly as the wood stove has died out completely.

A few hours pass, I wake up with a start: the sheets seem wet. I am horrified and hurriedly check the concerned body parts. To my relief all is well. Unable to identify the source, I long for the soft sheets, comfy pillow and cosy duvet back in my Cambridge house. Eventually I creep out. The sky looks like a diamond-studded cloak. It is quiet and peaceful. I go back and wait for the sunrise.

After the morning tea, I raise the matter of my damp sheet in an attempt to resolve this mystery. "That must be Mini the naughty goat," says Manjula, as she bursts out laughing. "She enjoys relieving herself on an unsuspecting guest in the middle of the night." As we embark on a trek to the fields for the morning job, she



is still giggling. On the way, we pass a few fenced areas advertising the upcoming holiday home project.

During my fieldwork, I have observed that the physical landscape of a village is beginning to change, with new fences and luxury villas. Money from land sale is opening up new business opportunities such as shops, restaurants, beauty parlours, wedding halls and renting of houses for a few villagers, but at the same time poor people like Parubai are losing the additional income through fodder harvesting as large areas are fenced off.

When we return, Parubai's husband is busy getting the goats ready for a grazing trip. I suspect one particular member of the herd giving me a mischievous look. A few metres away, I see the land broker from the previous evening with a man wearing expensive sunglasses. "Very good plot, road-touch, clear title," I hear him say...

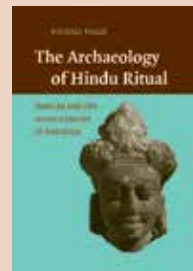
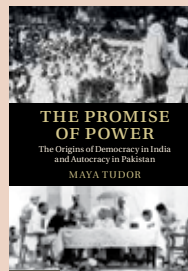
Girija is a Gates Cambridge Scholar and is also funded through a Fitzwilliam College Environment Studies Fund.



Girija Godbole
Department of Geography
gjg29@cam.ac.uk



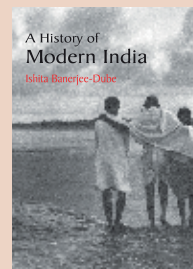
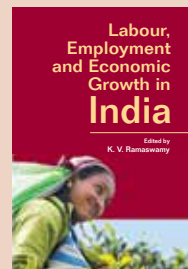
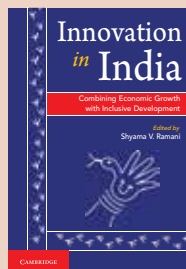
CAMBRIDGE
UNIVERSITY PRESS



India

Research at the highest levels
of excellence from scholars
around the world

www.cambridge.org/india2015



Read these articles and more at
journals.cambridge.org/India2015



- Spoiled Brides and the Fear of Education: Honour and Social Mobility among Dalits in South India
- New Spirituality, Politics of Self-empowerment, Citizenship, and Democracy in Contemporary India
- Sanskrit for the Nation

Available for **free** until end of 2015

T +44 (0)1223 765 443
E research.horizons@admin.cam.ac.uk
W cam.ac.uk/research
f [facebook.com/cambridge.university](https://www.facebook.com/cambridge.university)
t twitter.com/cambridge_uni
y [youtube.com/cambridgeuniversity](https://www.youtube.com/cambridgeuniversity)
i [instagram.com/cambridgeuniversity](https://www.instagram.com/cambridgeuniversity)

Contact

Research Horizons
Office of External Affairs
and Communications
The Pitt Building, Trumpington Street
Cambridge, CB2 1RP

Cover

Queuing to vote in India; find out more about India's vibrant and engaged democracy – the largest in the world – on p. 22 of this special issue on India.

