EDITOR'S NOTE

For our tenth issue, we had originally planned to focus on the humanities. This was supposed to complement our D.D. Kosambi lecture series, as well as our newly introduced lecture series named after the 14th century Indian mathematician and astronomer Madhava. The D. D. Kosambi lectures are delivered by eminent scholars in the social sciences, the arts and humanities, and the Madhava lectures by distinguished scholars on the history of mathematics, science and technology.

However, as this issue goes online, India and the world are engulfed by a one-in-a-century global pandemic. As science will play the key role in humanity's response to this crisis, it was impossible to exclude COVID-19 from this issue. So we included a speech given by K. VijayRaghavan, who is the principal scientific adviser to the Government of India, a professor emeritus and the former director of the National Centre of Biological Sciences, Bangalore. We also have answers from Gautam Menon to a series of questions our readers might have about the pandemic, especially in the Indian context. Menon is a professor of physics and computational biology at Ashoka University and Institute of Mathematical Sciences, Chennai.

Apart from this, we have articles on Emperor Ashoka by Nayanjot Lahiri, about the environment and urban water by Sharachchandra Lele and analytical methods to understanding history by Tarun Khanna.

I would also like to take this opportunity to mention the multi-institutional, multi-lingual science communication initiative called CovidGyan. The initiative is a collaboration between the Tata Institute of Fundamental Research (and its centres including ICTS and NCBS), the Indian Institute of Science (IISc) and Tata Memorial Centre (TMC) and several other partners. The website https://covid-gyan.in is the outcome of this initiative. The website 'serves as a hub to bring together a collection of resources in response to the COVID-19 outbreak. These resources are generated by public supported research institutions in India and associated programs. The content presented on the website relies on the best available scientific understanding of the disease and its transmission.'

Fig. 1: General illustration of Contact Tracing based off of CDC-material. | CREDIT - CFCF, CDC

With efficient, speedy and action-oriented contact tracing, we can be step ahead of the virus: K. VIJAYRAGHAVAN

K. VijayRaghavan is the principal scientific adviser to the Government of India. He is also professor emeritus and the former director of the National Centre of Biological Sciences, Bangalore. He has been a part of the ICTS-TIFR Management Board since its inception. Here are excerpts from his speech about Aarogya Setu, an integrated data and decision support platform to fight the COVID-19 pandemic, on the digital platform Digital India Learning.

These are very difficult times and at the outset it is important to be clear that difficult times are best handled with intelligence, calm and resoluteness. And that is what all of us are doing. It is pretty incredible to see how we have all come together to fight this pandemic.

How did this pandemic come about?
The COVID-19 disease is caused by the SARS-Coronavirus2. There are other coronaviruses that we know of – like SARS1. SARS2 is different from SARS1 in many ways. SARS2 seems to have been transmitted to humans via two animal hosts – probably bats and

pangolins. We know this because we can analyse the genetic sequence of the virus in humans. We can go back and ask how is the sequence related to those that are being isolated from other sources of transmission such as a bat or a pangolin. Therefore, with a very high level of accuracy we think this is the route of transmission. We can also look at the variations as the virus spreads from country to country, continent to continent. And then we can track where the spread started from and how it travelled to other countries. We know that it originated in Wuhan, Hubei province, in China in December 2019 and then rapidly went to other places.

There are many important points that we must keep in mind – about why this disease has wrecked such havoc and why we are so concerned about it. If you look at the absolute numbers of deaths by COVID 19, many people argued till a few months ago that the mortality rates expected were similar to those of a major influenza pandemic or of heart disease or tuberculosis. So why are we so concerned about this? The reason for that is not the absolute numbers alone but the exponential growth. The rise from a low number to a very high number in a very short time, which overwhelms each location where this growth takes place rapidly. The resources, the hospital environment, the economy is put under great stress when this exponential growth takes place very rapidly. So imagine there is a manufacturer who can manufacture a very large number of components – let's take the example of Haldiram's or another similar company. If they manufacture a very large number then adding, let's say, 10 per cent of the number may not seem like a huge increase. But if you make a significant and sudden demand at many local outlets, which is huge and disproportionate to the capability of the outlet, then you cripple the supply system or the ability to handle the demand. That is what is happening with COVID 19 disease. The infections ramps up very rapidly because each person spreads it to a few others, who in turn spread it to a few more. And if you don't do anything then the spread can be very rapid.

So the next question is what do we do?
If the presence of the virus and the symptoms of the disease are very tightly associated in time, then attending to the symptoms would also attend to the spread of the disease. So you can easily isolate someone who has the symptoms and ensure that the disease does not spread. Then if you isolate all those around them who are likely to be infected, then you can be very confident that the disease will not spread. When SARS2 infects people and many of those people have no symptoms at all. Even when they have no symptoms they can infect others. The spread is insidious and therefore looking at only those who have symptoms doesn't quell the pandemic. So you will need to have other kinds of tools to do that.

What are the kinds of tools we have?
Broadly, there are two kinds of tools. One is a defensive tool and the other is offensive. The defensive tools are – because the virus spreads through droplets or there are speculations that it spreads through aerosols (that's why the use of masks are more important than earlier thought necessary) – isolation or social distancing, washing hands thoroughly, not touching your face with unwashed hands, and after touching your face washing your hands again. These kinds of rules allow you to prevent the rapid propagation of the virus. Under these situations, instead of a rapid rise you can 'flatten the curve' – prolong the disease spread but lower it's intensity. But the important point is that the disease is still there. You need to have offensive ways also by which you can remove the disease. Of course it's possible that if everyone were to stay very far away from each other for several months then the disease
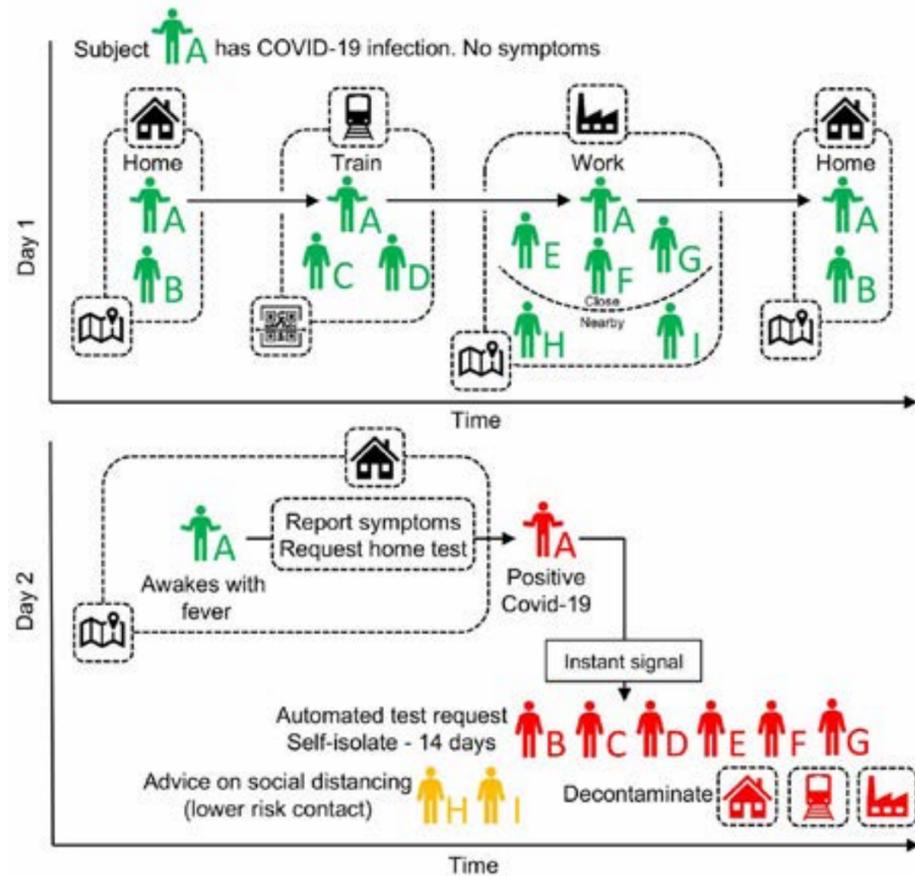

Fig. 2: A schematic of app-based COVID-19 contact tracing [REFERENCE - "Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing", Luca Ferretti, Chris Wymant1, Michelle Kendall, Lele Zhao, Anel Nurtay, Lucie Abeler-Dörner, Michael Parker, David Bonsall, Christophe Fraser | IMAGE SOURCE - Wikipedia]

would die off. But that's not feasible at all.

What would be the feasible way then?
In the long term we hope to have vaccines and drugs against the disease. The route to the vaccination seems to be going reasonably well right now. Drugs of course are much more difficult for viruses. This is because viruses, especially this kind, use the host's cell machinery almost entirely for its growth. So any drug designed to attack the virus is very likely to attack the host's machinery. Therefore, it is difficult to get a unique drug. Even if you manage to get a unique drug that damages the host minimally, you need to attack the virus at the early stages of the infection. At the later stage the virus will have multiplied in large numbers. So it is important to hit early, but it's difficult to know when. These are the challenges – but a vaccine and perhaps a drug will surely come.

So what is the offensive way we have now?
We have a two-component offensive weapon and that's called 'testing and tracking.' If we can trace every single contact of a person who tests positive and do that backwards in time, we need to do this because asymptomatic people can also infect. When a person was asymptomatic they may have infected some people. Later when they test positive you can go back and say look when you were asymptomatic, you were

close to these many people, these people have to watch out and we have to monitor how they are doing. If this method of contact tracing which is a variation of the classical manual contact tracing, is done we can isolate people who are likely to have been infected. The speed at which the disease spreads and the suspected speed at which asymptomatic people can transmit it, means that contact tracing must be done very rapidly. For it to be effective, it needs to be done on scale and really well. Contact tracing then allows people to be tested if needed. Testing also needs to be robust and effective and on scale. Both these are happening. The government has rolled out a new way of contact tracing called Aarogya Setu. It's an app available on Android and Apple stores. And this is not only for smartphones. Today a feature phone version was rolled out in Tamil Nadu and will be available all over the country very soon. This will allow contact tracing along the lines that I have just told you. If you download the app and do a self-assessment – age, gender, history of diseases, recent international travel – then you get an assessment of where you stand in terms of vulnerability. The app will have all this information on the phone and when its Bluetooth, GPS are on. If you come close to variety of people that information is not used until someone turns positive amongst your proximal contacts, and then you are told that a few days ago you were close to a person
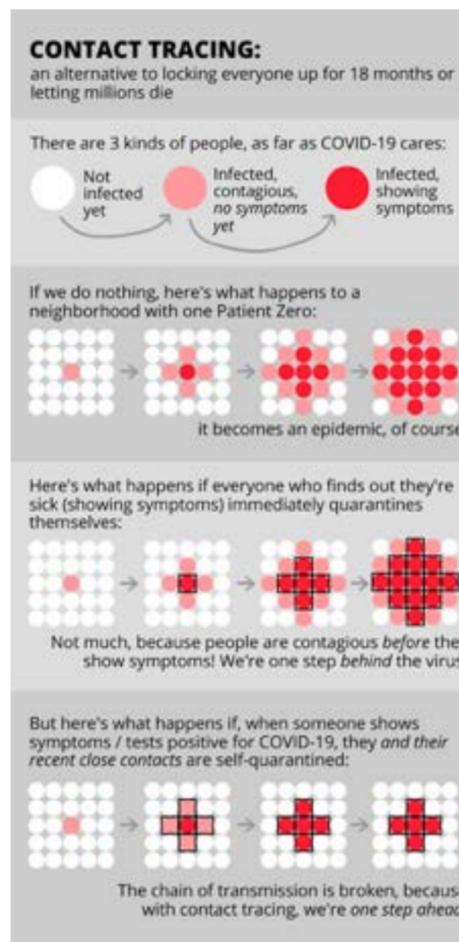

Fig. 3: Contact Tracing helps us break the chain of virus transmission, and stay a step ahead.

who became positive and you need to do certain things – look after yourself, isolate, need to get tested or be careful depending on the nature of the contact. Your phone number and contact details are known to no one, nor are the details of those who turn positive known to you. There is high security, high privacy, yet there is a high level of ability to trace and deal with the disease. If necessary people will be tested, and then they will be contacted. This scale and quality of contact tracing is really unusual, it's been done on a national level. But for it to be effective a very large number of us should use it. Everyone who has a smartphone or a feature phone should be using this app in one way or another. This is very important.

This is an integrated data and decision support platform. Unlike many other diseases, asymptomatic people can transmit so a way to track every close contact of those who are positive is needed. And like I said this needs to be done backwards in time.

How does contact tracing work?
Imagine someone, say Person A, leaves by train to work and then comes back home again. All is well. The next day this person reports symptoms and requires a test, which turns out to be positive, then there is

an instant signal which goes to all those people who were close to that person during commuting, at work or at home. And the people who were a little far away are warned. Keep in mind why this is so important and why you should not look at only those who are showing symptoms. There are three kinds of people – those who are not infected yet, those who are infected and contagious but don't show any symptoms and those who are infected and show symptoms. And if we do nothing then this is what happens [slide] – a person who is asymptomatic but positive becomes symptomatic, infects other people who also later on become symptomatic and the epidemic spreads. Now if you quarantine everyone who has symptoms and nothing else, then you will be quarantining only the red people [see slide]. There will always be the asymptomatic people who will still be spreading the disease. You don't know who they are and it's not possible to test the entire population. You need to have a way of focusing as this pink person travels over various distances, over time. We need to find out who all were close to that person and warn the others after the person is identified as positive. This is what contact tracing is – it will find the symptomatic person and also identify all the asymptomatic people around him in the past two days and quarantine them too.

So contact tracing and testing are both very important, so that you don't needlessly quarantine those who are not positive but you test those who are proximate to the person who is positive.

With efficient, speedy and action-oriented contact tracing, we can be step ahead of the virus. With the defensive tools of mask wearing, face covers, hand washing and social distancing, we are one step behind the virus. But when we combine this with contact tracing and testing we can go one step ahead effectively. Only digital tools can make this possible, in the time, quality and scale needed, and India excels in this. Therefore, the wide use of Aarogya Setu allows alternative to long-term lockdowns and can prevent the health system from being overwhelmed. It has great speed and quality in collection of data, in analysis, decision making and action. It is on a national scale and integrates every single body on the ground – integrates disease surveillance system, the National Centre for Disease Control, state health systems, public health systems and feeds the information along with the data from Aarogya Setu go rapidly back to decision making. The collected data will be used only for COVID19 and not for anything else. The security tests have been thoroughly done, the security is assured.

By combining the efforts of our extraordinary health workers with a digital tool, we will stay one step ahead of the virus while we work hard nationally and internationally to develop a vaccine. □

COVID-19 DATA ANALYSIS BASED COMMENTARY

Several members of ICTS-TIFR have been involved in developing a new website which presents a data analysis of the COVID-19 confirmed cases and deaths in a set of 10 countries, including India. The aim of the website HTTPS://WWW.ICTS.RES. IN/COVID-DATA-COMMENTARY/ is to come up with a simple quantitative way of assessing the growth of the pandemic and the effect of control measures. It is proposed that the exponential growth rate (closely related to the doubling time of the disease) could provide such an observable. This website monitors on a daily basis the confirmed number of cases, deaths and their exponential growth rates in these ten countries. Comments are added regularly on notable changes one observes in the evolution of the pandemic. The idea of the website is also to give a broad overview of the evolution of the pandemic and to see if one can make educated guesses on what to expect in the Indian situation, from what one sees for other countries.

The people involved are Arghya Das, Abhishek Dhar, Srashti Goyal, Jitendra Kethepalli, Kanaya Malakar (Brandeis U.), Sriram Shastry (UCSC).
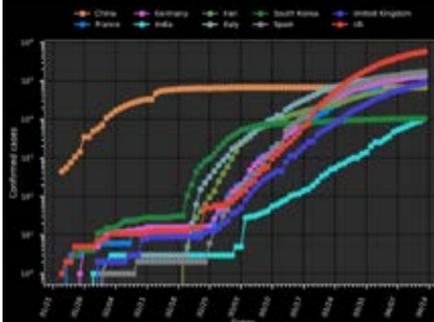

Fig. 4: Data of the 10 countries considered in this study
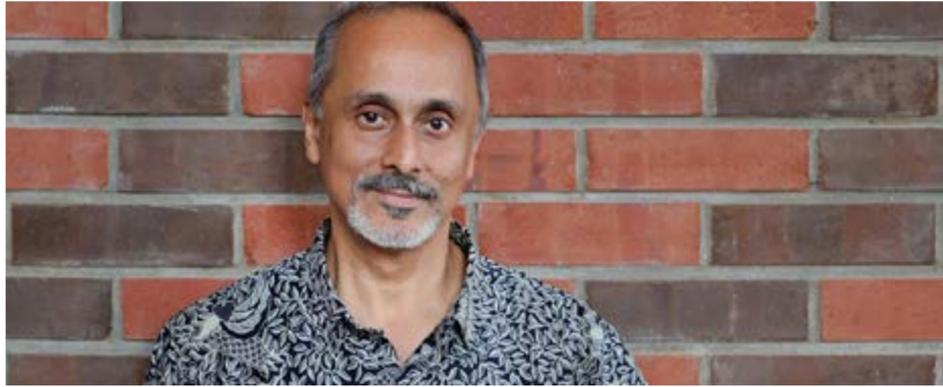
The only solution is large-scale testing:
GAUTAM MENON

Gautam I. Menon is a professor of physics and computational biology at Ashoka University, Sonepat, and the Institute of Mathematical Sciences, Chennai. In the interview with Ananya Dasgupta he answers our questions about the global pandemic COVID-19, especially in the Indian context.

Q: *What can be done to prevent a similar pandemic in the near future given that the present one had its origin in a wet market in Wuhan, dealing with consumption of wild animals?*

GAUTAM MENON: There are many reasons to shut down those parts of wet markets that deal with exotic and endangered species, the possibility that novel viruses could jump from animals to humans under such conditions being only one of them. Better surveillance for potential emerging diseases, strong basic research funding for laboratories to study them in the intervals between outbreaks, more attention to ecological issues connected to the destruction of habitats and implications for the animal-human interface, and far more attention to the determinants of a high quality public health system that can be used by rich and poor alike would all help us deal better with a pandemic in the future. The One Health initiative of the WHO is particularly important in this regard, since it recognizes that an integrated multi-sector approach, combining public health, animal health, plant health and the environment is the best way to deal with emerging public health challenges.

Q: *We hear that the regular flu virus mutates so rapidly that a vaccine made for one year's flu season has very limited use the next year. Do we know yet how fast the coronavirus mutates? Are there already many distinguishably different strains of the virus? If so, do some strains have a higher mortality rate than others? How is India placed in this regard?*

GM: SARS-CoV-2 (which is the virus that causes COVID-19 and the virus we mean when we say 'coronavirus') is an RNA virus, so it mutates at a faster rate than DNA viruses. The coronavirus doesn't seem to be mutating very fast, perhaps about 4 times slower than for influenza, but the influenza virus does have a

more complex (segmented) genome with many more options for re-assortment. There are already multiple distinguishable strains of SARS-CoV-2 and these have been used to identify when the virus was introduced into different countries. We have no information about whether the different strains are noticeably different in terms of their virulence. We don't have data for India yet because of a lack of sequences (only 4 so far) and no ability to correlate the strains to patient records to determine changes in virulence.

Q: *Is there an Indian effort to make a vaccine against the coronavirus? If so, which labs are leading this effort?*

GM: I'm not knowledgeable about the ongoing vaccine efforts in India, although I am sure the NIV in Pune and the NII in Delhi, to name just two organizations that will be able to, are both working on vaccines. The large-scale efforts are from outside India. The multi-national coalition for epidemic preparedness (CEPI) is funding eight vaccine technology efforts, from Curevac, Inovio, Moderna, Novavax, the University of Queensland, the University of Hong Kong, Oxford University and an Institut Pasteur-led consortium. There are a large number of initiatives going on apart from these.

Q: *What is a realistic timescale for the development and testing of a vaccine? Once a vaccine has been developed and validated, how long would it take to produce billions of shots of the vaccine?*

GM: The development of a vaccine, pre-clinical testing and the sequence of phased trials to assess safety and efficacy should take between a year to 18 months in the best case scenario. My guess is that ramping up production should not be a rate-limiting factor, given the high levels of public and private support to make

an inexpensive vaccine available to the world.

Q: *Given the fact that most slum dwellers in - e.g. Mumbai - live in very cramped apartments and also share water and toilet facilities, is there any chance that a lockdown can be successfully implemented in urban Indian slums?*

GM: The challenges posed by very dense urban agglomerations is a huge challenge for epidemic control at all times. The current strategy of a large-scale lockdown will be hard to implement there for any length of time. The only - and best - solution is large-scale testing to identify those infected, as well as those immune because of having caught the disease earlier.

Q: *Do any of the epidemiological models of the spread of the virus make a serious effort to incorporate Indian realities - e.g. the near impossibility of social distancing in urban Indian slums - into their equations?*

GM: No, none of them do, currently. Some work that we are doing currently using agent-based models with very detailed information about a specific urban slum region for which we have data should help us understand this question better. This model can be extended to other regions if we have information about them.

Q: *The lockdown in Italy seems to have been pretty successful - the daily growth of infected people is now below 3 per cent, significantly lower than a couple of weeks ago. If the lockdown were to be eased tomorrow, however, wouldn't the rate of infections pick up again?*

GM: That, in general, will be the case — in that case numbers will rise post-lockdown. The idea of the lockdown is to be able to isolate individual cases and quarantine them while imposing a high level of social distancing by fiat to halt the epidemic. If all cases can be identified and quarantined so as to prevent further spread, that would severely slow or even halt the epidemic in its tracks. However, this is typically infeasible and there will be some stealthy growth in the number of cases, typically asymptomatics that our current policies of identifying potential people infected will not access. Thus, numbers should be expected to grow again once the lockdown is withdrawn. Virtually all models I know of predict this.

Q: *We are now over 3 weeks into the Indian lockdown. Is there any evidence from the figures that the lockdown is beginning to work? Can this be quantified in any way?*

GM: There seems to be a slight leveling off of the number of cases per day but I would certainly not risk saying this definitively. We have too little data to tell. Also, we have no idea of the spread of the disease among patients who remain asymptomatic.

Q: *What effect do you think the large scale movement of migrant workers had on the spread of the disease? Has this reality been incorporated*

into any of the epidemiological models that try to predict the progress of the disease in India?

GM: We don't know what the background levels of infection are, given that asymptomatic individuals may form 75 per cent or more of cases, and we certainly don't know the extent to which these migrant workers might have been infected. Absent this information, it is impossible to model this effect at any convincing level. Models we are currently working on look at flows of people between states and how the migration of infected people might promote the epidemic in places where it has not reached yet. But these models must make certain assumptions and it isn't clear which input numbers might represent reality.

Q: *Are antibody tests (as opposed to antigen tests) being used in India?*

GM: The ICMR page lists 7 antibody-based rapid tests that have been validated by the NIV. To my understanding, these have not been used at scale yet but imagine they will be very soon; there's nothing to prevent this. The bulk of current testing is being done using the real-time-RT-PCR method.

Q: *We hear that the rate of testing of the infection in India is one of the lowest in the world per capita? Why is the case? Presumably the low rate of testing means that the official figures underestimate the extent of the spread of the disease in India. Would you be willing to venture a guess for the extent of the underestimation? Is the true number of infected people likely to be twice, or ten times or a hundred times the official figures?*

GM: My own guess is that it is significantly higher. Somewhere between a factor of 10 and 100 would be my own guess.

Q: *Is the official count of the number of deaths due to COVID in India likely to be more reliable than the count of the total number of patients? Or is it plausible that several deaths take place outside hospitals and so are not recorded?*

GM: We don't know this and there are many problems. One is the fear of stigmatization, so patients would avoid going to a doctor in the first place until it might be too late. The other is the fact that most patients who die have comorbidities, such as cardio-vascular conditions or diabetes or some respiratory condition, so it's not necessary that the death will be recorded as having been due to COVID-19. So I'd think it's plausible that the count of COVID-19 associated deaths is underestimated, perhaps severely, although we don't know.

Q: *Do you know whether hospitals in parts of India are beginning to report a noticeable rise in the number of severe cases of pneumonia in India?*

GM: As far as I know, based on anecdotal evidence, there have been no reports of an unusually large number of cases that are straining ICUs, say of patients with COVID-like symptoms or general
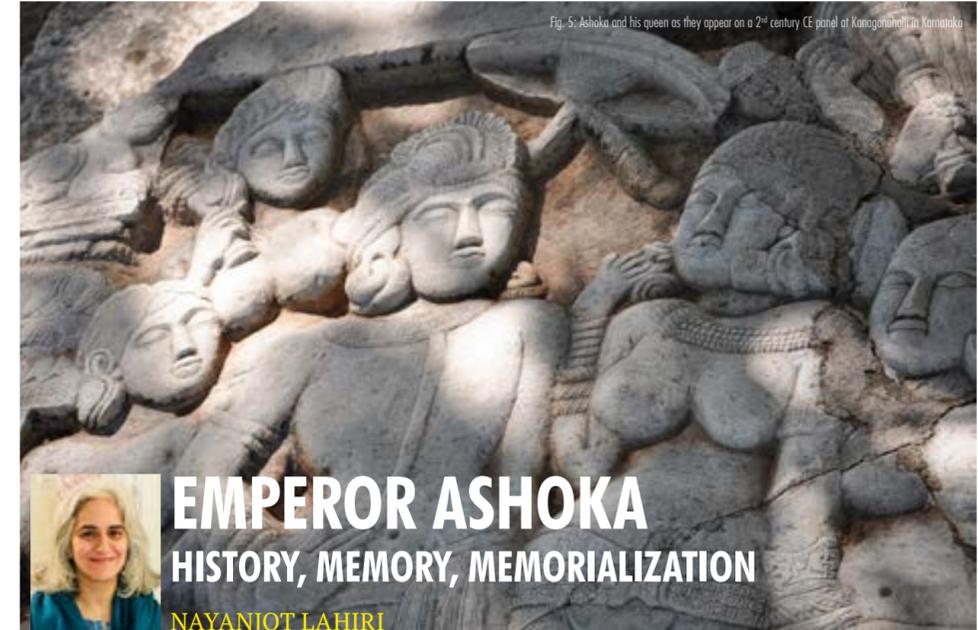
Fig. 5: Ashoka and his queen as they appear on a 2nd century CE panel at Kanaganahalli in Karnataka

EMPEROR ASHOKA
HISTORY, MEMORY, MEMORIALIZATION
NAYANJOT LAHIRI

The subject of my article is that rare and remarkable ruler who is the subject of a book I have written and in search of whom I have frequently travelled around India and sometimes beyond. I will explore the interplay of history and memory in relation to him – both in relation to his life and after he passed away, in the diverse contexts in which he was remembered. There are three themes that I will explore. The first relates to why historians depend on a remembered past in order to reconstruct the life of Ashoka. Second, I will look at how memory and remembrance of things past figure in the Ashokan edicts themselves. And finally, after the emperor passed away, I will look at the various ways in which he came to be memorialized. Here as also in Ashoka's own messages, memory appears to be more reconstructive rather than reproductive, based less on 'what happened in history' and more on contemporary presuppositions and mindsets.

Ashoka is someone whose enunciations were inscribed in public spots and they are found in fifty odd places. Rocks and pillars, inscribed on the instructions of the emperor dramatically underline that the king wanted his subjects not to imagine him as a remote presence in a faraway capital but as something real on a rock down the road where they lived, in the vicinity of where they worshipped and along routes that they travelled through.

Beyond his own time, Ashoka was remembered across India and across Asia. At Kanaganahalli in Karnataka where he is identified by name – as 'Raya Asoko'. Ashoka figures in the accounts of Chinese pilgrims like Faxian and Xuanzang, in the 12th century Kashmiri chronicler Kalhana's Rajatarangini. And Ashoka is also mentioned in Abu'l Fazl's famous Ain-I Akbari. So, if his historical imprint during his own lifetime is subcontinental, his remembrance also is subcontinental. And beyond India too Ashoka regularly pops up – in indirect ways, as in the presence of

dharmachakras, some of which were mounted on pillars, in the time of the Dvaravati culture, as also at relic stupas in China. The Famen stupa, when it collapsed in 1981 revealed a crypt which, among other things, contained a finger bone relic which, according to legend, was supposed to have been originally distributed by King Ashoka in what was called 'the Ashoka Stupa'.

Because I have begun with a montage where I have combined various elements in relation to Ashoka's life and his afterlife – his life as a communicator king and his afterlife where he came to be remembered through art and through chronicles– this can create an impression that with these sorts of imprints and texts, writing about him would be a fairly uncomplicated exercise where there is a clear demarcating line between history and memory. Where the words that he got inscribed could be used for writing about the historical Ashoka, and his remembrance to understand the tenacity of the memory of Ashoka. This impression actually is an illusion.

For one, while Emperor Ashoka's excursions into public communication are very many and often very elaborate, they pertain to just a few years of his life – from somewhere around 260 BCE till around 243 BCE. They cover some seventeen years of a long life lived from the cusp of the fourth and third centuries BCE till around 232 BCE. This means that there are huge chunks of Ashoka's life and his reign for which there are no contemporary written records. This difficulty is not specific to Ashoka, it is precisely the package of problems that exists in relation to ancient rulers. For Alexander, the most relied upon history that we have is by Arrian which is 2nd c CE. Compared to Alexander, Ashoka's edicts are a positive treasure trove.

Fig. 7: Migration routes during partition

Migration Routes

Official — Foot, Rail, Plane, Sea

Crowdsourced — Foot, Rail, Road, Plane, Sea, Multi-stop

A PAEAN TO LEARNING TO "SEE"

TARUN KHANNA

The famous biologist Edward Wilson, an emeritus professor at Harvard University, wrote a book named Consilience. The book is about bringing together knowledge bases and the ultimate idealized notion of unity of all knowledge. Of course, it is not a new construct, but Prof. Wilson tried to breathe new life into it. I will try to illustrate in this article, using a variety of examples, as to why consilience matters in most walks of life

About ten years ago, the then-Provost of Harvard University asked me to build an institute that connected the University to all the South Asian countries — from Afghanistan to Burma — known today as the Mittal Institute at Harvard. The idea was to build bridges across all disciplines with the countries in this region. That was the beginning of my journey into the empirical interpretation of the idea of consilience.

Regarding the process of intellectual discovery, the prominent mathematician Andrew Wiles said: *"It's all about groping and probing and poking, and some bumbling and bungling, and then a switch is discovered, often by accident, and the light is lit, and everyone say, 'Oh, wow, so that's how it looks,' and then it's off into the next dark room."* This catches a lot of the excitement for me. The mystery, the surprise, and the serendipity of it.

The naturalist Henry David Thoreau, of my local Cambridge milieu, albeit many years ago, spent hours and days, weeks and months, simply walking around Walden Pond with a notebook and lenses of all sorts in his hand, simply cataloging things. He said: *"We must look a long time before we can see."*

The philosopher Immanuel Kant, in his famous Critique of First Reason, wrote: *"Immerse yourself in experience, surrender yourself to doubt."* It is very difficult to make progress purely as a theorist. Ultimately, you have to immerse yourself in the phenomenon of interest.

Another example is Pablo Picasso's series of paintings on the bulls. He started the painting probably copying Francesco Goya. But it didn't look right to him. Picasso didn't think that another attempt inspired by the French painter Durer's "Rhinoceros" was quite right, either. He decided to dissect the animal, likely drawing inspiration from ideas of geometry. In the next iteration, it is not hard to see the influence of the French painter Andre Matisse, who was painting in single lines. Iteratively, he then arrives at his minimalist final bull. This iterative arrival at what Picasso was the essence of his preoccupation at the time is not so different from an intellectual journey that a scientist or an artist takes.

Just like in To Kill A Mockingbird, Atticus Finch says: *"You never really understand a person until you consider things from his point of view … until you climb into his skin and walk around in it."*

Take also the example of the Italian painter Michelangelo Caravaggio. Caravaggio was one of the prime exponents of the technique called *chiaroscuro* — the interplay of light and shade. This was the time that Galileo Galilei was beginning to question the prevailing geocentric model of the universe based on his use of an elementary telescope. Caravaggio was very influenced by Galileo's preoccupation with light. He set himself up in a studio, most probably

somewhere in Florence, and put a mirror in front of him. Then he stared into it and painted himself. Over and over again. Experimenting with different forms of light, with contrast. This, in turn, influenced people who were studying what we would today call the physics of light, optics. This is an example of consilience being a normal part of everyday society. At least in Florentine Italy.

Let me give you some contemporary examples: If you are a physician-in-training at the Harvard Medical School, you are now likely to spend time at Boston's Museum of Fine Arts as part of your core curriculum. The idea is that you have to learn to "see" a patient, and not simply reduce the patient to a set of symptoms, measurements, or diagnostic device readings.

For the past decade, I have been teaching a course at Harvard called Contemporary Developing Countries. The idea is to pick some of the most difficult problems of economic development in the poor countries of the world. For example, the prevalence of corruption, the lack of clean water, or the difficulty of getting vaccinated. Then imagine it as an abstract problem, think about how to approach it, attack it, and empirically think about how to devise a solution that would benefit millions of people. This is the task of the course — it has become quite popular and it has evolved into quite a lovely format. It is now taught by an applied mathematician, an artist, a physician, a scientist, and an architect. All of us form a team and teach it together. We take the same problem and see it through a variety of eyes, through the lenses of a variety of different disciplines. The architect comes with a particular disciplinary lens, the artist comes with

another. A jazz musician might approach it differently. And you might say that this guy is engaged in a silly exercise, because what can an artist possibly have to say about the availability of clean drinking water? But it turns out that the artist approaches a problem with a different sensibility and ends up with ideas that do not necessarily occur to the water engineer or the public health specialist.

Since the 70th anniversary of Partition of British India two years ago, there has been a resurgence of interest in that event. My family suffered the direct impact of Partition; both my parents migrated from what is now Pakistan. I have always heard stories of what it was like. Of course, it is something that has been studied extensively by historians and political scientists.

The event inspired some of us at Harvard to revisit the eternal question: What is history? The novelist S. Namwali wrote recently in the New York Times: History is *"[T]he word the English used for the record of every time a white man encountered something he had never seen and promptly claimed it as his own, often renaming it for good measure."*

E.H. Carr, in his book What Is History, says, *"The facts speak only when the historian calls on them: it is he who decides which facts to give the floor, and in what order or context."*

These sentiments inspired us to look anew. When we look at the scholarship of the Partition, it is true that on one hand it is very erudite and accomplished, but it is also clear that the scholarship inevitably privileges written sources of information, likely connected much more to those who were able to record their experiences directly or through others. What about the views of many more teeming masses who suffered the depredations of the Partition? So, a colleague and I, both emanating from applied mathematics, decided to study this historical phenomenon through a different lens.

We recorded oral history interviews with the survivors of Partition. And we used that as the data source. We should acknowledge at the outset that memory itself is problematic sometimes. A colleague at Harvard, Daniel Schachter, in his famous book, Searching for Memory, wrote: *"Memories are records of how we have experienced events, not replicas of the events themselves."* And Oliver Sachs, the neurologist and brilliant writer who passed away quite recently, reminds us: *"Memory arises not only from experience but from the intercourse of many minds."* It's a function of how you experience a particular event rather than a literal presentation of the events.

Anyway, we set out to find people who had survived Partition across contemporary Pakistan, India, and Bangladesh, as well as the South Asian diaspora in the United States, the United Kingdom, and elsewhere. Remember, it's been 70 years, and the person needed to be at least 5-10 years old at the time to have any memory of it. So, today they would be knocking on the doors of their 80s. We tried to get them to speak to

us whatever came to mind about the Partition, largely unscripted, rather than responding to a questionnaire. This will become a data source of more than 2,000 hours of oral memories of the Partition of British India. For the first time, a single study has brought together the unvarnished memories of Pakistanis, Indians, and Bangladeshis in a format amenable to research.

We must remember that this is the largest involuntary migration in recorded human history. Much bigger than the human crises going on today. The official British record of the death toll was a few hundred thousand people, and their estimate was that 3 million people crossed the borders. Contemporary studies from carefully pieced together data say that it's more than 16 million people who moved, and with much higher mortality rates — in the millions — than previously reported. Right there you see the limitations of the existing data sources.

We also mapped out reconstructions of migration paths based on the oral story. We have about 1,000 of these reconstructions.

It turns out that organizations like the United Nations should be interested in these analyses — including the reconstruction of migration paths — because they are dealing with refugee crises and camps all the time. And here they have a dataset to think about how you can house involuntary migrants, where you would construct the taxonomy of refugee camps ranging from places where somebody stays for 2-3 days, transit camps where they stay for 1-5 months, temporary settlements, to residential rehab which is usually more than 5 years. Many of these residential rehabs become part of the urban economy, absorbed into cities. One of my architect colleagues has been tracing the urbanization of northern India and Pakistan and showing that a lot of the contours of contemporary cities bear the signatures of these forced migrations.

Let me give you another example, the Maha Kumbh Mela. One of these religious celebrations was held in Allahabad in 2013, at the confluence of the Ganga, the Yamuna, and the mythical river Saraswati. In January–February, the river recedes its banks and clears out a space in an unpredictable fashion. But once it's clear, an entire city has to pop up to house the Kumbh Mela. How many people come to the Kumbh Mela? It turns out nobody knows. So, we did a detailed study of how many people come to the Kumbh Mela and could find no systematic quantitative analysis of it, including by the people who administer it. There are numbers thrown around. So, with a biostatistician, we came up with a quantitative estimate of daily attendance and cumulative attendance. We could only estimate what we can call lower bounds, a cumulative attendance of 61 million, and a peak daily attendance of 25 million.

So, under the Mittal Institute's auspices, about 70 academics from Harvard University visited this amazing event. We pitched a tent and stayed collectively for 30-40 days. There were scholars of religion, law, political science, history, mathematics,

THINKING ENVIRONMENTALLY ABOUT URBAN WATER

SHARACHCHANDRA LELE

When we think of 'environmental problems' we think of climate change, biodiversity loss, deforestation or air pollution. Some of them seem remote, some only occurring in places like Delhi, some the creation of rich Westerners. But come summer in the Indian sub-continent, a problem that comes to the fore is water scarcity. Government agencies then announce big projects to 'solve' the problem. But is 'scarcity' an adequate descriptor for the water problem? And is 'building one more pipeline' the solution? Urban water issues are complex and multi-dimensional, and truly 'environmental' thinking calls for us to unpack and address them more holistically. Let's see what this entails and what insights we get when we apply this approach to water in Bengaluru (previously known as Bangalore) city.

Environmental values, science, and world-views

Environmental thinking involves thinking 'holistically' at three levels: values, science, and worldviews. First, at the level of values, it demands that we think not just about water scarcity or *adequacy* in some generic and immediate sense, but also about *quality*. Moreover, it pushes us to think about:

a) the inter-generational dimension, i.e., *sustainability* of the resource,

b) the intra-generational dimension, i.e., *fairness* in the distribution of the resource and the pollution impact of resource use by one on others, and

c) the inter-sectoral dimension, i.e., the multiple claimants on water including not just human material needs but also *conservation* of non-human organisms.

Environmental thinking also highlights that since the sharing of water (or any other natural resource) across time, space or sectors will always involve trade-offs, one has to also think about the *decision-making process* that one espouses for resolving these trade-offs, and *decentralised, democratic processes* are clearly preferable. Thus, a comprehensive formulation of the goals for the water sector might look like Fig. 8.

Note that, at the end of the day, these are ethical choices, not scientific claims, even if they are informed by environmental science and social science. For

Fig. 8

instance, we would not be thinking about sustainability if the science did not show that unsustainability was imminent!

Second, at the level of science, environmental thinking demands that we acknowledge that there is 'no free lunch' nor any 'waste' in ecosystems. We, therefore, incorporate resource limits and limits of assimilative capacities for pollution, ecosystem thresholds and interconnectedness into our analysis. In the water context, at the very least, this means incorporating

a) the impact of upstream dams and diversions on downstream uses and users, and the possibility that even water flowing 'waste' into the ocean actually serves a purpose,

b) the impact of groundwater pumping on stream and river flows, and

c) the impact of knee-jerk solutions such as building more recharge structures or deepening tanks on downstream flows.

'Environmental' science also tells us that water cannot be created or destroyed in any significant quantities, that freshwater can be created from de-salination but at huge costs, while wastewater can be purified and reused (theoretically several times) at a relatively low cost. This science also alerts us to the need for thinking about use-specific quality, not just quantity.

Furthermore, the science dimension includes not just natural or physical science, but also social science. Environmentally-oriented social sciences provide proximate and deeper explanations for the persistence of environmental problems in the form of the 'externality' argument of environmental economics, the political ecology explanations from sociology, the misfit between environmental processes and institutions pointed out by political scientists and the emergence of consumerism explored by socio-psychologists. In the water context, 'hydro-politics' explains why water often flows not downhill but towards the powerful actors in society, while pollution flows away from them. The downward spiral of groundwater is explained by the open-access nature of the resource due to a legal regime favouring unfettered access.

Finally, world-views come into play when understanding is limited. Socio-environmental systems such as densely populated and rapidly urbanising river basins are complex, and involve much uncertainty. Environmental thinking suggests adopting a *precautionary* principle in the face of such uncertainty. So rather than assume that one can continue to modify the hydrological cycle by building large dams and diversions, carrying out inter-basin water transfers, and using up all the non-renewable or 'fossil' water that exists, environmental world-views urge that we err on the side of caution, allow some river flows into the oceans, try to make the most of the renewable groundwater we have, and limit our thirst as much as we can. By definition, world-views are not exactly scientifically proven assertions, but meta-scientific positions that are probably influenced as much by our ethics as by proven science.

Analysing Bengaluru's water situation

In applying this approach to understand Bengaluru's water situation, we start with some basic facts about the context, then 'evaluate' the situation vis-à-vis our multiple values, and then 'explain' it through the science and social science of water, before drawing upon our world-views to provide recommendations.

Bengaluru's 'official' water supply, amounting to 1350 million litres per day (MLD), comes from the Cauvery River that is 110 km away and 300 m downhill. But this does not tell the full story. On the one hand, of the 1350 million litres per day (MLD) that are pumped from the Cauvery River to Bengaluru, only ~50% reached consumers in 2017, of which ~15% then goes to commercial, industrial and institutional consumers, leaving ~565 MLD for the almost 1 crore population. On the other hand, precisely because Cauvery supply is inadequate, households and other users in Bengaluru (and even the municipality itself) pump out a lot of ground water—about 670 MLD in all. There is also a small amount of recycling of treated wastewater. Thus, the domestic sector uses about 995 MLD (And all of this is 'applied water'—we do not have good estimates of what rainwater gets directly consumed by vegetation.) Acknowledging the use of groundwater and treated wastewater is itself a first step towards thinking holistically!

From an adequacy point of view then, average water domestic consumption in Bengaluru works out to about 120 litres per capita per day (lpcd) which is somewhat lower than the official goal of 135 lpcd but still looks reasonable. But this average hides significant inequity in water use:
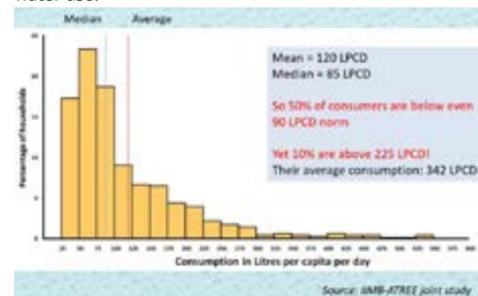

Fig. 9

The median consumption is ~85 lpcd, which means half the population is below that value, including many below 50 lpcd! At the same time, the top 10% consume at an average of 340 lpcd! Clearly, equitable access is a far cry as of now. The issue of water quality is more complex: Cauvery water supply is by and large of near-potable quality, while groundwater is more variable, with high levels of Total Dissolved Solids (which make water 'hard') being the norm, and pockets of severe contamination in industrial areas or near sewage leaks. On the other hand, industrial pollution is high, but the impacts are felt by downstream farmers, again highlighting the unfairness angle. But pollution, especially domestic sewage, severely affects the quality of water in the Vrishabhavathi River and in most of the lakes in Bengaluru, making it almost impossible for fish and other biota to survive in most of these water bodies—a negative for biodiversity conservation goals.

How sustainable is Bengaluru's water supply situation? There is no imminent threat to Cauvery supplies: although climate change models suggest declining rainfall in the Cauvery basin, water for urban use always gets highest priority and is therefore relatively assured. But it comes at a huge electricity cost, and therefore indirectly at a GHG cost. And groundwater use is clearly unsustainable, especially in the periphery, where pumping is high and levels are dropping rapidly, as the groundwater monitoring by Muddu Sekhar and others from IISc shows:
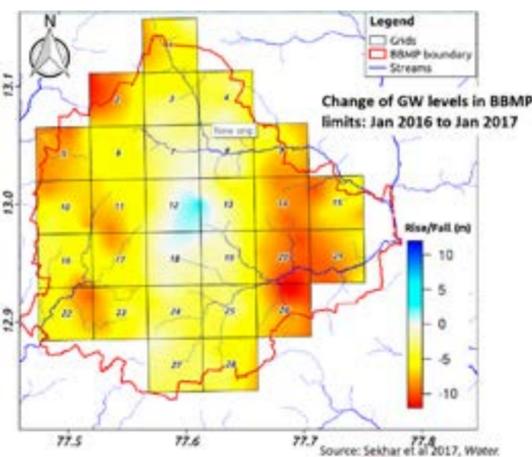

Fig. 10

Finally, when it comes to democratic governance, the citizens of Bengaluru neither have a direct say in the governance of the Bangalore Water Supply & Sewerage Board (BWSSB), nor are they even consulted when BWSSB plans large projects for supply augmentation or sewerage. Even the two hundred-odd lakes in the city were not in the custody of the municipality till recently, and their 'rejuvenation' plans continue to be drafted by consultants and fishing rights in them continue to be auctioned by the Fisheries department, with no say for citizens living around those lakes.

Clearly, we are far away from meeting our goals on most fronts. But does this mean that 'Bengaluru is going to die' as some newspaper reports recently suggested? Hardly. But some people (the poorer

sections) will definitely face a heavy burden as water becomes scarcer, and/or Bengaluru may impose a heavy cost on the hinterland as it tries to appropriate more water from further and further away.

Why are we in this situation and what is the way ahead? The moment we mention water scarcity, many look for 'economic' solutions, arguing that water is too cheap. But in fact Bengaluru has been one of the first cities in India to install water meters for most of its connection and introduce volumetric charging and Bengaluru's water tariffs are amongst the highest in Indian cities. Our analysis with Deepak Malghan (IIM-B) showed that users are unlikely to respond to further price increases in public supply, because of the peculiar situation that rich people can anyway afford to buy tanker water if needed, and poor people have anyway cut their consumption to minimal levels. Inequity in consumption is driven by lack of access to piped supply in slums or lack of storage in poor households, which in the face of intermittent supply places a major constraint. The sharing of connections in lower-income households that results in high marginal prices is also a factor, as is the absence of apartment-level metering in apartments with bulk connections.

Pricing may appear to be a problem when it comes to sewage disposal—the amount users pay is far from the average operational costs. But while low pricing can explain fiscal deficits in the BWSSB, it cannot explain malfunctioning sewage treatment plants or choked sewer lines, which are a direct consequence of inadequate monitoring and no penalties from the pollution regulator. Citizens also think of sewage as 'out of sight, out of mind'. Poor monitoring and weak enforcement are also the cause of high industrial pollution.

Unsustainable groundwater use happens for multiple reasons: the absence of any monitoring of groundwater use (especially by commercial users), the absence of even distribution of Cauvery water (or even leaked Cauvery water!) leaving the periphery of Bengaluru to fend for itself, and declining recharge rates due to paving/cementing of land surfaces in the absence of any norms by the municipality.

The deeper cause, driving these policies (or their absence), a fragmented (river water focused) and supply–side mindset in BWSSB and in turn the inability to reform the agency is due to the absence of a voice for citizens and independent experts in urban water governance. Perverse policies such as penalising households if they do not carry out rainwater harvesting rather than rewarding them if they do, are a consequence of inadequate social science input into and accountability in policy-making. This is the story of urban water everywhere in India, but in large cities like Bengaluru the creation of a specialised water agency and heavy investments in infrastructure result in engineering mindsets, inertia and vested interests, preventing change.

Correspondingly, the solutions proposed by BWSSB continue to be on the supply side: building another pipeline from the Cauvery, or from much further away (the Yettinahole project, or the Hemavathy reservoir). The rhetorical device of calling everything 'drinking water' and therefore making it sound an absolutely non-negotiable human need is coupled with a discourse that focuses on averages, and not on distributional issues or governance. An alternative discourse is, however, emerging that is pushing for an integrated approach: better use of local water—rooftop rainwater, stormwater collected in lakes and increased groundwater recharge—with demand side measures in high consuming households, better distribution of Cauvery water, especially to low-income households, and treatment and reuse of wastewater at multiple scales, along with efficient use of imported Cauvery water. This approach could obviate the need for large, environmentally disruptive, economically unviable and unfair water transfer projects. Implementing these ideas will, of course, require concerted citizen mobilisation and democratisation of urban water governance.

In other words, environmental thinking or holism is not just about integrating across values or disciplinary divides, but ultimately across the knowledge-action divide itself.

Further reading:

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Savenije, H. H., 2002, "*Why water is not an ordinary economic good, or why the girl is special*", Physics and Chemistry of the Earth, Parts A/B/C, 27(11): 741-744.

Shah, Mihir. 2014. "*Urban Water Systems in India: A Way Forward.*" New Delhi: ICRIER.

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Sharachchandra Lele is the distinguished fellow in Environmental Policy and Governance at the Centre for Environment and Development. ATREE, Bangalore.

BETWEEN THE SCIENCE

statistics, public health, medicine, architecture, urban planning. The sadhus must have thought we were crazy, but we simply located ourselves there. We watched and measured, made movies, engaged respectfully. Of course, as a Hindu, I participated in the religious ritual. It was just another exercise in learning to see the world the way somebody else sees it.

This was the first Maha Kumbh Mela with cell phones. Sadhus with computers. And what an amazing database that would have been. We had to go through enormous contortions to get access to anonymized data regarding the occurrence of cellphone calls and texts, in a way that satisfies Indian law. Bharti Airtel folks were unbelievably helpful. And a whole lot of interesting studies emanated from these efforts.

We wrote a paper on the idea of homophily. Remember, Hindus from all over India and the world come to the Maha Kumbh Mela. Since we had some data about the cell phones, we could tell which area someone came from. What we were able to show is that if you are from a part of India that is relatively underrepresented in this massive crowd, you end up sticking together even more than if your "type" is more fully represented. And this tendency is exacerbated on the more crowded days. This analysis of social and spatial homophily has pretty direct implications for traffic flows and crowd control.

We also realized that this was a setting where we could learn about public health issues, primarily how to take steps to prevent epidemics, and how to study chronic disease incidence given the enormous numbers of folks, especially in proximity to each other. We eventually engaged with the Ministry of Health on these issues.

We showed that if you put in place rudimentary sensors in select spots in the rivers, those you can buy for a few rupees, you can get indicators that are correlated with subsequent outbreaks of gastric distress. Perhaps this could lead to preventive measures and alleviate distress and expense. Remember that you have as many as 25 million people in one place at peak daily attendance moments. So, if a disease sets in and kicks off, it can be a real problem.

We also demonstrated that we could test people for the incidence of chronic diseases like diabetes in such settings and develop population maps of such diseases. The device in question was a result of some novel science and engineering, created in a tribute to consilience, through a seven-year effort by physicists, chemists, computer scientists, doctors, engineers

and design specialists, in a company I co-founded, called Janacare. Janacare is Boston-based and has a Bangalore-based engineering department. We called our device Aina [Hindi for mirror], and it can be plugged into any smartphone. Suppose you are in a remote place with no hospital. There's a good chance you have a phone. You just need a drop of blood to get tested with Aina. This device is now commercially available in India.

In addition, Aina was accompanied by something that we called *Habits* — the idea of which was if you had this small device, you could measure yourself wherever you were and upload that data to the cloud, and somebody could analyze the data and figure out if something was going on with your health. Or in principle, you could do that at the population level and see if there were problems arising in particular locations.

Now we can test at the community level, we can screen, stratify people, treat them, monitor them. We can now construct metabolic maps of areas, simply by seeing where this device is available. Say, unsurprisingly, areas around Cubbon Park or Lal Bagh in Bangalore have a much lower incidence of diabetes. Plausibly, this is just because there are more active, walking around, and exercising. That's just a simple correlation.

Let me give you another example. A colleague from MIT and one from IIT-Delhi and I teamed up to create one of the very first machine learning applications for remote talent assessment, a company called Aspiring Minds (Gurgaon based, with offices in Beijing and San Francisco today). We built this into an organization, a research arm and a commercial company to provide decentralized tests of all sorts of things so you could measure capabilities and aptitudes of folks normally left out of the mainstream of national economies. And the applications for this are endless. For instance, entities in several countries, some state-owned and some private, approached us about the problem they had with less-skilled migrants. They wanted to know if there was a way they could be tested to see what their aptitudes were for different avocations — to direct them into different jobs.

Some of the really interesting tests Aspiring Minds' researchers came up with were for vocational skills — for farmhands and agricultural workers, for drivers and plumbers. These involve testing not just for what I'll call domain knowledge and cognitive skills, but also for motor skills of different sorts. The latter is a first, I believe. The motor skills were tested via creative games on tablet computers. The idea behind these

games is that you have to move your arms, shoulders, and wrists to play the game properly; this in turn reveals dexterity of different sorts.

At some point, colleagues in the Prime Minister's office and Niti Aayog asked me to come up with a policy for some sort of structure for entrepreneurship in India. Is there a way in which you could use policy levers at the level of the government of India to nudge people to embrace creativity? In my mind, this is akin to developing an affinity for consilience, though you may not quite call it that! And as the Partition, the Kumbh Mela, Aspiring Minds, and Janacare suggest to you, my bias is to bring people of different kinds of intelligences together and get them to work on complicated problems. Philosophically, I believe that complicated problems usually have a variety of causes, and the solutions usually will elude any single skill set. So, we came up with a report, which had many parts to it. It resulted in an organization called the Atal Innovation Mission (AIM), which is now housed within the government's Niti Aayog.

One part of AIM that has really worked well are so-called tinkering labs. Just like at the Kumbh Mela, where we put up a tent and people of all sorts came together and played intellectually with ideas to come up with all sorts of novel scholarships, we are doing this is high schools across India. Thousands of schools across the country — rural and urban, rich and poor — have got tinkering labs to inculcate the spirit of scientific enquiry among children. Instead of studying science the way in which I was taught in my school days in India, not particularly inspirational, the tinkering labs are handmaidens to creativity in science. The kids are absolutely amazing, unsurprisingly. All you have to do is to put different sorts of material, simple 3D printers, laptops, and microscopes, and they can run loose. Superimposed on this is a so-called Mentor Corps, where adults from the community volunteer their time to mentor kids in the labs. They don't need to be scientists to do so.

I hope these diverse examples gives you a sense of why I think learning to "see" requires an appreciation of consilience. Our over-specialized academic world needs a dose of inter-disciplinarity. As Americans say, that's "motherhood and apple pie." The question is: how do we make it happen? That's my quest. I hope you join it!.

Tarun Khanna is the Jorge Paulo Lemann professor at Harvard Business School and the director of Harvard University's South Asia initiative.

However, it is in handling this peculiar challenge in reconstructing ancient lives that memory comes in, and why memory gets to be used in order to write history. Personally, for me, the challenge was, how was I to fill in the blanks when large parts of Ashoka's life had actually not been chronicled in his lifetime? I had to find a credible way of recovering him from the knot of legends and concoctions built around his persona much after his time, from texts like the Ashokavadana (c. 2nd CE) and the Singhalese Buddhist chronicles, the Dipavamsa (c. 4th CE) and Mahavamsa (c. 6th CE). So, some of my travels with Ashoka involved experiencing and assessing the landscapes that I felt were central to understanding later textual traditions which had taken threads from those landscapes to embroider different episodes in his life. After all, those stories too, as told centuries later, would have had to sound credible. So, a little outstanding accurate detail would have helped in adding credibility to a later elaboration of a past event.

That was why I went to the Barabar hills in Bihar. These hills have a connection with the religion of a figure who had predicted that Ashoka would become the ruler in Ashokavadana, the legendary biography of the emperor and in the Sri Lankan tradition. In one of those stories, his 'coming' as emperor of India was predicted even before his birth, and it was an Ajivika who had predicted this, while elsewhere it was an Ajivika called Pingalavtsajiva who, after examining various princes, told Ashoka's mother that he would succeed his father Bindusara. Because the Ajivikas are a sect that has 'vanished', since the religion, unlike other faiths with ancient roots, has no modern adherents, much less is known about it. In the latter part of the first millennium BCE, it was a very powerful religion, and its central tenet was predestination, in which human effort had no place. But coming back to the legendary histories, why an Ajivika acted as the augur and not, for instance, a Jaina or even a Brahman can be understood from what we know about

the historical Ashoka through his monuments and epigraphs. He donated caves to the Ajivikas in these hills. These are no ordinary caves but were created through a substantial outlay of money and men, by hollowing out granitic outcrops and mirror polishing the walls). Because of their architecture, these caves enhance every sound inside. As many of you would know, it was this tendency of the caves to echo so unusually that is so central to E. M. Forster's *A Passage to India* where one of the characers, Mrs. Moore, dies with the echo of the caves in her head while another, Adela Quested, is misled by the echo into believing that she has been molested.

Again, there is the image of Ashoka as a serial stupa builder that figures influentially in these texts and across the centuries in many parts of Asia. Ashoka has most often been been credited with opening up the original stupas built over the Buddha's relics and 84,000 stupas is the number suggested for what he built over the redistributed relics. This obviously is an imaginary number meant to suggest that he did get many relics redistributed and lots of stupas built over them. In dealing with this, one of the questions I asked myself was whether there was any evidence about the act of opening up the old stupas? Actually, in the core area of early Buddhism, an archaeological excavation by B.P. Sinha and S.R. Roy in 1969 had shown how such relics were removed.

This was at Vaishali which is where the Buddha came on a number of occasions. The oldest part of the religious landscape of Vaishali is the relic stupa, the one where they were said to have placed their share of the Buddha's relics. The stupa was built between the sixth and fifth cs. BCE and was then constructed out of mud, it was subsequently enlarged on four different occasions with bricks. Excavations confirm that in Maurya times, the Vaishali relic stupa was dug into for some reason. Hypothetically speaking, there are many possibilities that one can consider in imagining

how the stupa was breached - from mischief done by a group of miscreants in unsettled times to a deliberate desecration by a rival religious group. However, in either case, there is no reason then why the relic casket with its contents would not be smashed. But the casket is intact. Part of the relics were removed from it and, once again, it was re-interred inside the stupa. In literature, it was Emperor Ashoka who ordered this to be done.

But, whichever way one looks at these incidents from the literary life of Ashoka, these are highly inferential – where we sort and arrange memories and speculate about his life by weaving them into a context, based on monuments or on archaeology, in order to compensate for the lack of a historical Ashoka. So, memory comes into play not merely when one looks at how Ashoka came to be remembered after his death but also in trying to say something about those phases of his life about which sources are silent.

The historical Ashoka emerges when one enters the comfort zone of hard evidence, when he began composing his edicts and getting them inscribed – and there are at least two aspects to the historical life of the emperor and its various twists and turns and landmarks that are worth noting. The first part concerns Ashoka as a communicator par excellence, communicating about a new morality and about a new concept of governance.

The emperor decided, at the outset, to get multiple copies of his message prepared and sent to various provinces - this ensured that the message had a massive reach. Here was a ruler who was attempting to create an image of himself via words of his message, his attempt being to convey the same image of himself in every part of his empire. What this communicator par excellence put out in the public domain was also amazing. To just mention a few. First, Ashoka's own keenness to appear to posterity not as imperious but as a flesh and blood emperor is utterly novel. The

Fig. 11: Dharmachakra at Nakhon Pathom

Fig. 12: Erragudi rock edict - part of it

big war that he won at Kalinga, is recorded by him as a disaster because of the collateral slaughter. The king sees himself as the chief villain of the carnage, and I can think of no other ruler who snatched defeat in this way from the jaws of victory. Second, is his interest in ensuring the welfare of all living beings. His fifth pillar edict is the most substantive royal message anywhere in the ancient world for the protection of living beings. Finally, there is (12th major rock edict) the Ashokan idea that dhamma is about a public culture in which every sect honours every other. He is obviously trying to advance the notion of a fundamentally new kind of political and social community.

The second part of his historical persona concerns Ashoka's avatara as a Buddhist emperor. In some epigraphs, his Buddhist persona is dramatically visible. He visited places of Buddhist sanctity in the Nepal terai such as Lumbini, as also in the Gangetic plains including Sarnath and Bodh Gaya. At Sanchi and at Kaushambi, he presented himself as a spiritual regulator and protector of Buddhist unity opposing divisions (samghabeda) among monks and nuns. At Bairat where the king even offered advice on religious expositions and the confidence with which he suggested that the monks and nuns focus on listening and reflecting on particular dhammic expositions makes it seem as if he sees himself as the Buddha's preacher-successor. What I am trying to say is that there are two pivotal images that the historical Ashoka put out in the public domain - that of a compulsively communicative engaged with all living beings as also a Buddhist sovereign with the power to impose discipline among the Sangha.

As we go into how he was remembered after he passed away, it will be evident that the communicative emperor faded away while the Buddhsit persona remained.

But if one stays for a minute with his words, one may also ask that in his enunciations, where does memory figure? Is there in the Ashokan edicts a remembrance of things past? The past does figure in Ashoka's words – in relation to the consequences of the new morality or dhamma that he promoted and also, in the slipstream of some major episodes in his own life. So, for instance, in the first communiqué, his message presented the success of his mission and his life in terms of what had transpired. There is an emphasis on highlighting that whereas in preceding times, humans and gods had not mingled, now the king had made the intermingling possible. He himself incidentally is shown here as making a graduated progression as a Buddhist. Where he looks back to his own recent past, to say that a year or so ago, he had become zealous because of his interaction with the Sangha. The past state of his kingdom as also the past state of his mind are invoked in order to emphasize his own transformation and his self proclaimed mission to pursue the promotion of moral zeal among his subjects.

The vivid juxtaposition of the features of a progressive present with the invocation of memories of a less edifying past is more dramatically emphasized in his major rock edicts. To just give you a couple of examples, earlier 'for many hundreds of years, slaughter of lives,

Fig. 13: Vaishali pillar with Sri Lankan tourists around

cruelty to living creatures, disrespect to Sharamanas and Brahmans increased'. Now, what had increased was 'abstention from the slaughter of life, absence of cruelty to living creatures, seemly behavior to Shramanas and Brahmanas, obedience to mother and father (and) obedience to the aged'. Again, while in the past, we are told 'kings set out on vihara yatras or pleasure tours' where hunting and other such pleasures were enjoyed. But now, tours of morality were undertaken or *'dharma-yatras'.*

Interestingly, Ashoka does not publicly remember many things about his own past – neither his parents nor the circumstances which brought him to the throne. Why then are some memories privileged and others ignored? What is clear to me is that the past that he reconstructs is one through which he seeks to highlight his self-willed departure from it, and his present dhammic zeal and agenda look far more impressive because it has this backcloth of a backward remembering gaze. Memory had intentionally been woven into the texture of the epigraphs because by constructing a particular kind of past the interventions of the emperor are made to appear by him as a watershed.

After his death, whether his ideas of humane governance were followed by his successors is not known, it seems unlikely and in fact, the successor kings rarely appear as rounded historical subjects. But what we do know is that Buddhism continued to prosper, and it is in the historical texture of its monuments that Ashoka comes to be arrestingly imaged.

Sanchi is one example of this where one gateway of the great stupa of the four that were built a few hundred years after Ashoka's time, chose to memorialize him in sculpture. It shows Ashoka's visit to the Ramagrama stupa. Legend says that he travelled there to take possession of one of the original relic deposits of the Buddha but the Nagas successfully resisted him. On the western pillar of the southern gateway, again, Ashoka is shown, this time on his visit to the Bodhi tree. In both instances it is his Buddhist persona which is imaged. Ashoka built the original brick stupa below the stone

cladding at Sanchi, so he already had a connection with the place. Which was consolidated by such carvings.

How was he remembered in those areas with which he had no connection?

Actually, Ashoka was often invoked in certain parts of southeast and east Asia, regions that don't figure in his edicts. Rulers towards the west – from those of the Selucid kingdom to Macedon do figure but there are no references to the lands towards the east. And yet, he is most frequently remembered there. In fact, in one temple in Bagan in Myanmar he is more often depicted than in places like Sanchi or elsewhere in the Indian subcontinent.

There is at the Myinkaba Kubyauk-Gyi temple built by Rajakumar, the son of Kyanzittha, of the 12th century CE with elaborately painted interiours. The subjects range from the Jataka tales, also scenes from the life of the Buddha to the lives of many kings where Ashoka figures rather prominently, with labels identifying him. So, on the northern wall of the entrance archway, there are four panels around the life of Ashoka in India. One which says that *'This is king Dhammasok'*, another which says that this is king Kalanagaraja (a Naga king mentioned in the MV). He creates a likeness of the Buddha, and shows it to king Dhammasok. In another part of the temple, Ashoka figures in relation to Sri Lanka. We are told *'in the island of Singhala, king Devanampiyatisa was reigning. He was a friend of king Dhammasok. King Dhammasok sent him regalia (including) 3 shoulder loads of water of Anowatat and other precious things…. Another panel which mentions that when king Dhamvmasok wishes to send the relic of the tree with Theri Sanghamitta, to the island of Singhal… with the story of the great ocean and the Nagas there…'* Ashoka also prominently figures in relation to a third theme that of the Buddhist Councils. So, in connection with the the third Buddhist Council, there is Moggaliputta Tissa performing miracles for 'king Dharmasoka), and there is another one where Ashoka wants the monks to be told to hold the uposatha festival'. But, as one can see, it is Mogaliputta Tissa who is the main subject, and Ashoka is

there along with a whole lot of other figures.

How should we imagine these frescoes? This remembrance clearly is connected with Buddhism. But it should be seen as Buddhism plus something else. In Myanmar, Buddhism is a presence from the time between the 5th and 7th centuries CE just as in Thailand it goes back to the 6th and 8th centuries. Bagan, however, became the political capital in the middle of the 11th century, with king Anurddha at the helm. Some decades later, after the rule of Man Lulan (son of Anurddha) in the time of the third ruler, Kyanzittha, Rajakumar, made this masterpiece. Rajakumar was Kyanzittha's son but knew that he would never succeed his father because when Kyanzittha claimed the throne, he apparently promised that his heir would be the offspring of his daughter's union with the Mon prince (whose support he had been crucial in his accession).

Rajakumar, however, became a remarkable scholar. He set himself to master the full range of Theravada literature, cosmology and history, and to show his knowledge spectacularly and clearly in his temple. He uses paintings, each with explanatory glosses and the whole giving a picture of world-history as known to the Buddhists of those days in the texts, and covering India and Sri Lanka. That is why Ashoka figures here. Rajakumar also did what many scholars do: he engaged with the text, probably dropped the parts that didn't interest him and then added bits that made the story more personal – so, he brought it up to the time of the king, Anuruddha, who his father had served as a general. The Singhalese king who was a friend of Anurddha, was Vijayabahu who died just about the time when this temple was being built, is imaged there. In any case, through the temple, Rajakumar makes his own knowledge and mastery of the texts explicit, immortalizing himself for posterity, even as he knows that he can never be king.

A different pastiche of memorialization can be seen in Thailand. Among all that I surveyed, the real learning experience for me was in south Thailand where rulers bore Ashoka's name from the 12th century till the 14th century. These were kings known as Sri Thammasokarat (Sri Dhamma Ashoka Raja evidently) with their base at Nakhon Si Thammarat (the city of Dhammaraja). Nakhon today is a relatively small town and hasn't received a great deal of historical attention, but it was one of the various experiences in my travels that made me look beyond just looking for Ashoka.

The chronicles of Nakhon Si Thammarat – translated by David Wyatt as the *The Crystal Sands* - are grounded in the most sacred Buddhist shrine there – Wat Mahatat - record that long ago two Indian cities disputed the possession of a Buddha tooth relic and an Indian prince Nondakumara and princess Hemachala of the city which lost the war fled with it to Lanka. The boat they were travelling in capsized and the sea, anxious to conserve the relic, cast it and its guardians at a place called the Beach of Crystal Sand that would become Nagara Sri Dhammaraja. A little later, they on advice from a mahathera took it to Lanka but the boat in the middle of the sea could not go forward and the boat's crew,

thinking that these two were responsible, aimed to kill them. They were saved by the same mahathera and to cut a long story short, the boat sailed on, the relic reached Lanka but the ruler then got four brahmanas and the these two to sail away – one part came to the crystalline beach and the other went back to the city from where they were originally. Incidentally, some crucial components of Wat Mahatat, such as the wide hemispherical dome, the square base surrounded with statues of elephants, represented strong influence of Sri Lankan art of Polonnaruwa period (c. mid 11th till mid 13th centuries).

According to the chronicles of Nakhon, the first ruler of this dynasty with his family and elsewhere came and established themselves here in order to escape an epidemic. He founded Nakhon in the 12th century and also constructed a chedi. There is also a Thammasok II who arranged for the restoration of the temple and also planted Bodhi trees and there is a Thammasok V who also concerned the rebuilding of the great stupa here. As perceived by its local chroniclers, the earliest history of Nagara Sri Dharrmaraja has nothing directly to do with the empires of classical antiquity of Southeast Asia, Angkorian Cambodia, Srivijaya or Bagan. What gave these chroniclers the confident sense of continuity which bridges numerous abandonments of the principality and ties together what may seem to be disparate material is their utter conviction that Nagara Sri Dhammaraja was blessed with the sacred presence of the corporeal relics of the Buddha. It is this basic holy presence and local identity wrapped around it which is the starting point of how the state came to be constituted and fitted in with its local environment.

Till this point the story seems to resonate with elements of the legend of Ashoka in my mind with the caveat that while the Indian Ashoka built 84,000 stupas, here the chronicle is around the building of only one stupa. However, very soon, there is a twist in the story where, the chroniclers shown the Indian Ashoka in a supplicant's role vis-à-vis the Dhammasokaraja of Nagara Sri Dharmmaraja. Apparently, a messenger came bearing a letter from the ruler of the Middle Country – called Sri Dharmasokaraja, a man of immense merit, whose queen was Sandmitra. He had apparently erected 84,000 reliquaries, he knew the principles of Buddhism, could translate from Pali for meaning as well as the monks could but he had no relics to enshrine. He also said that the Dharmasokaraja of south Thailand should erect a very high reliquary. But this latter king was greatly troubled about how he would provide for relics and at this point, an elderly man, more than a 100 years old, came forward and identified the place where the original relics had been buried. So, those were got out and the ruler then had relics sent to the Ashoka in India.

When a new dynasty has to present itself as having links with a much older formation, what are the devices that it chooses? What one witnesses is a phenomenon where a newly created political formation wishes to imagine itself as antique, it does so by looking back and binding the region and the kings with a larger geography around South Asia and relics, around the Buddha, and

around an ancient Indian king - Ashoka. And sometimes an interesting consequence of this can be twists in the story where the chroniclers see their own kings as being custodians of sacred power that is sought by this Indian king. So, the chronicle of Nagara Sri Dhammaraja is an inversion of the original story, and one which makes the Indian Dhammaraja beholden to his Thai namesake.

Here, perhaps, one should also look at the disjunction between chronicles and what exists on the ground. Situated in the isthmian tract between two oceans, it had the openness of an island to trade and cultural influences. Within the Tambralinga area, iron age sites in Nakhon, at least five of them, have provided Dong Song bronze drums in the 5th c – 1st c BCE context. So, in the iron age itself, there was maritime exchange with the areas to the east of it. Then, coastal Nakhon also presents the highest density of the Vishnu images of the conch shell on the hip style, being dated to around the fourth and fifth centuries CE. There is also a very impressive distribution of Hindu shrines in what is called the early Tambralinga period (c. 5th to 11th centuries CE). These are easier to identify than residential sites since they have bricks, stone architectural parts and statues. Hindu shrines completely outnumber Buddhist temples. There are only a couple of pure Buddhist sites, otherwise, Buddhist items have been found in contexts associated with Hindu shrines because Buddhism seems to have been incorporated into Hindu ritual spaces in the early Tambralinga period. An example of this is Wat Chom Thong where there is a 7th c Vishnu image and a 5th c Buddhist image. But there are also lots of Chinese ceramics dated from the 11th to 14th centuries. There are Vishnu shrines (Wat Phrang I) and statues. Even in the excavations at Wat Mahatat or Wat Phra That, three yonis (c. 5th to the 8th centuries) were also discovered in various areas in Wat Mahathat, some of them have been apparently incorporated in the monastery's rock gardens. P. Noonsook was probably right in assuming that the Great Reliquary was established on the former sacred place of Hinduism, where stone fragments and sculptures of the Hindu shrines can still be seen.

But, the point is, from this rich and diverse past, when a chronicler has to present the region and the links of its rulers, it is selectively done. The present and the past are presented but not in terms of the links that are so evident but by invoking a prestigious antique time in the early areas of Buddhism in South Asia. So if Ashoka's presentation of past times and rulers is a remembrance with a slant, the remembrance of Ashoka in medieval Thailand too is marked by those very features.

In conclusion, across time, then, remembrance, instead of reproducing events in a straight forward way, is a reconstruction based on existing presuppositions and cultural expectations. In fact, as I have continued to travel with Ashoka, I have felt that while the world beyond this emperor's time was peopled by cultures in communication and in creative dialogue, equally, their distinctiveness is part of the story. They have walked their own paths, plucking out symbols and beliefs and building up chronicles and compendia, temples and tall

MENON | *continued from Page 4 ...*

symptoms of respiratory infections, such as generic severe acute respiratory illness (SARI) or influenza-like illness (ILI). This is heartening if it's really the case, since it would suggest a milder trajectory for the epidemic in India. Whether this is still early days for the epidemic and whether rising numbers of serious cases might be seen only later, is a topic of discussion at the moment.

Q: *Fatality rates from the disease have varied greatly from place to place. For instance, fatality rates in Italy are on the higher side, while those in Germany are on the lower side. What is the reason for this difference? Where does India stand on this scale?*

GM: Italy is a somewhat different case because of its relatively larger fraction of elderly people who are at an increased risk, compared to, say, India. The countries that do better have universal public health, high-quality nursing care, very good follow up in contact tracing, a general faith in the public health system and good communication between the government and the citizenry. In India, I think we're doing a good job on some fronts, such as the way state machinery was mobilized for the lock-down. Communications from the Prime Minister convey the seriousness with which the government is taking the epidemic. We're not doing well on other aspects of communication and transparency and especially in making data available for scientists outside the government system to access. There is an epidemic of misinformation about the disease in India as well which many of us are making an effort to tackle, but this is not unique to India. □

Fig. 14: Wat Phra Mahathat

stupas in imaginative ways, ways which have a little to do with Ashoka and much more to do with their own dynamic ways of carving out cultural identities and framing political ambitions. □

Nayanjot Lahiri is a historian and archaeologist of ancient India and a professor of history at Ashoka University.
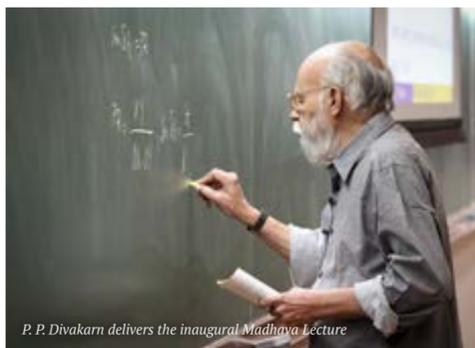
P. P. Divakarn delivers the inaugural Madhava Lecture

Priyamyada natarajan delivers Vishveshwara lecture

Uma Ramakrishnan delivers the KWK talk
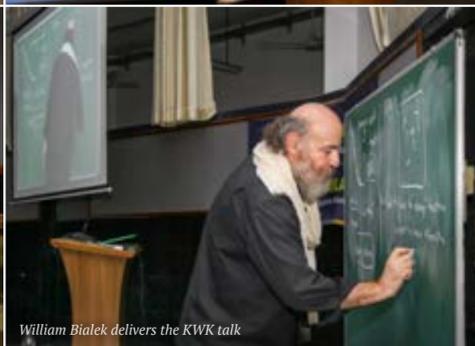
William Bialek delivers the KWK talk

LECTURES

MADHAVA LECTURES

The new lecture series named after the 14th-century Indian mathematician and astronomer Madhava was introduced with the first lecture by P.P. Divakaran. The ICTS Madhava Lectures will be delivered by eminent scholars in the history of mathematics, science and technology.

The Man Who Invented Calculus: The Life and Work of Madhava
14 February 2020 ✦ *Speaker* — P. P. Divakaran
(Formerly Professor of Physics at TIFR, Mumbai)

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23 December 2019 ✦ *Speaker* — Ashvin Vishwanath
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10 December 2019 ✦ *Speaker* — David Eisenbud *(University of California, Berkeley, USA)*

Computational Complexity in Theory and in Practice
18 October 2019 ✦ *Speaker* — Richard M. Karp *(Professor Emeritus, University of California, Berkeley, USA)*

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24 September 2019 ✦ *Speaker* — Marcelo Viana *(IMPA, Brazil)*

Falling/Rising Styles of Gravity/Buoyancy-Driven Disks
4 September 2019 ✦ *Speaker* — Jacques Magnaudet *(CNRS & University of Toulouse, France)*

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3–5 February 2020 ✦ *Speaker* — Nima Lashkari *(Purdue University)*

KAAPI WITH KURIOSITY

Global Warming in an Unequal World --The Economics and Politics of Climate Action
9 February 2020 ✦ *Speaker* — T. Jayaraman *(M. S. Swaminathan Research Foundation, Chennai)* ✦ *Venue* — J. N. Planetarium, Bengaluru

Of spooky actions and other quantum conundrums
12 January 2020 ✦ *Speaker* — Smitha Vishveshwara *(University of Illinois, USA)* ✦ *Venue* — J. N. Planetarium, Bengaluru

150 Years of Entropy
21 December 2019 ✦ *Speaker* — William Bialek *(Princeton University)* ✦ *Venue* — J. N. Planetarium, Bengaluru

Will Tigers Survive the 21st Century
10 November 2019 ✦ *Speaker* — Uma Ramakrishnan *(NCBS, Bengaluru)* ✦ *Venue* — J. N. Planetarium, Bengaluru

DD KOSAMBI LECTURES

Emperor Ashoka – History, Memory, Memorialization
16 January 2020 ✦ *Speaker* — Nayanjot Lahiri *(Ashoka University)*

A Paean to Learning to 'See'
25 November 2019 ✦ *Speaker* — Tarun Khanna *(Harvard Business School, Harvard University, USA)*

VISHVESHWARA LECTURES

Unraveling the Nature of Supermassive Black Holes
20 December 2019 ✦ *Speaker* — Priyamvada Natarajan *(Yale University, USA)*

EINSTEIN LECTURES

Order and Patterns in Randomness
28 February 2020 ✦ *Speaker* — Abhishek Dhar *(ICTS-TIFR)* ✦ *Venue* — REVA University, Bengaluru

Faint Strains of the Gravitational Wave Symphony and the Dawn of Multi-Messenger Astronomy
25 November 2019 ✦ *Speaker* — Bala Iyer *(ICTS-TIFR)* ✦ *Venue* — E.M.S. Seminar Complex, University of Calicut

Black Holes and Holography
22 October 2019 ✦ *Speaker* — Amin Nizami *(Ashoka University, Sonepat)* ✦ *Venue* — NIT Jalandhar

Millisecond Pulsars - The Born-again Pulsars
21 October 2019 ✦ *Speaker* — G. Srinivasan *(Raman Research Institute, retired)* ✦ *Venue* — IIT Madras

The revolutionary concept of "boundary layer" and its prevalence in aeronautics
11 October 2019 ✦ *Speaker* — Sourabh S. Diwan *(IISc, Bengaluru)* ✦ *Venue* — Acharya Institute of Technology, Bengaluru

String theory and Strong interactions
26 September 2019 ✦ *Speaker* — Loganayagam R. *(ICTS-TIFR)* ✦ *Venue* — Center for Post Graduate Studies (CPGS), Jain Deemed-to-be University, Bengaluru

PROGRAMS

Topics in Birational Geometry
27—31 January 2020 ✦ *Organisers* — Indranil Biswas and Mahan Mj

Workshop on Additive Combinatorics
24 February—6 March 2020 ✦ *Organisers* — S. D. Adhikari and D. S. Ramana

Fourth Bangalore School on Population Genetics and Evolution
27 January—7 February 2020 ✦ *Organisers* — Deepa Agashe and Kavita Jain

ICTP-ICTS Winter School on Quantitative Systems Biology
3—20 December 2019 ✦ *Organisers* — Buzz Baum, Guillaume Salbreux, Stefano Di Talia and Vijaykumar Krishnamurthy

Thermalization, Many body Localization and Hydrodynamics
11—29 November 2019 ✦ *Organisers* — Dmitry Abanin, Abhishek Dhar, Francois Huveneers, Takahiro Sagawa, Keiji Saito, Herbert Spohn and Hal Tasaki

Group Algebras, Representations and Computation
14 October—23 October 2019 ✦ *Organisers* — Gurmeet Kau Bakshi, Manoj Kumar and Pooja Singla

Smooth and Homogeneous Dynamics
23 September—4 October 2019 ✦ *Organisers* — Anish Ghosh, Stefano Luzzato and Marcelo Viana

DISCUSSION MEETINGS

7th Indian Statistical Physics Community Meeting
19—21 February 2020 ✦ *Organisers* — Ranjini Bandyopadhyay, Abhishek Dhar, Kavita Jain, Rahul Pandit, Sanjib Sabhapandit, Samriddhi Sankar Ray and Prerna Sharma

Moduli of Bundles and Related Structures
10—14 February 2020 ✦ *Organisers* — Rukmini Dey and Pranav Pandit

Geometric Phases in Optics and Topological Matter
21—24 January 2020 ✦ *Organisers* — Subhro Bhattacharjee, Joseph Samuel and Supurna Sinha

Fluids Day
20 January 2020 ✦ *Organisers* — Rama Govindarajan, Samriddhi Sankar Ray and Gaurav Tomar

Foundational Aspects of Blockchain Technology
15—17 January 2020 ✦ *Organisers* — Pandu Rangan Chandrasekaran

Statistical Physics of Machine Learning
6—10 January 2020 ✦ *Organisers* — Chandan Dasgupta, Abhishek Dhar and Satya Majumdar

Novel Phases of Quantum Matter
23 December 2019—2 January 2020 ✦ *Organisers* —Adhip Agarwala, Sumilan Banerjee, Subhro Bhattacharjee, Abhishodh Prakash and Smitha Vishveshwara

Astrophysics of Supermassive Black Holes
17—19 December 2019 ✦ *Organisers* — Parameswaran Ajith, K.G. Arun, Suchetana Chatterjee and Bala R. Iyer

Sphere Packing
31 October—6 November 2019 ✦ *Organisers* — Mahesh Kakde and E.K. Narayanan