civilizations" that Marxist historian Karl Wittfogel proposed in the 1950s. The extensive canal building in India occurred mainly under British rule in the nineteenth century, when the use of canals for transport and trade already faced competition from the expanding railway network.

So although Amrith makes a persuasive case that rains, rivers, coasts and seas shaped the history of India as much as they did that of China, they did so in different ways. That is reflected in the fact that mastery of water in India has never been closely linked to a 'heavenly mandate' of state authority, as it has in China. Understanding those distinctions — and perhaps the equally marked differences in water's role in the Middle East — might offer a broader understanding of how history and environment entwine.

Lurking behind these questions is the issue of how far science and technology can help us to understand and manage nature. Modern meteorology can be said to have begun with the British colonial government's efforts to predict the monsoon, although that particular goal is still challenging. (The sensitivity of the monsoon to patterns of global climate such as the El Niño–Southern Oscillation are only now becoming understood.) It's ironic that, just as weather science has started to yield dividends, the impacts of technological advance itself have made it urgent that we develop a longer-term forecast.

In India and China in particular, climate change is complicating the centuries-old struggle with water. Global warming is expected to intensify monsoons, increase weather variability, raise sea levels and melt glacial reservoirs. At the same time, the precipitous modernization and socio-economic development of both countries has exacerbated pollution, over-use and inequalities of access — as potently symbolized in the despoliation of the Ganges.

That's why histories of this kind are needed more than ever. Political, economic and historical discourse cannot just linger on statecraft and strategy, alliances and migrations, trade and war. Increasingly, the environment is central — and its role needs to be understood not through sweeping, Wittfogel-style theses, but with the kind of attention to local detail and nuance that Amrith exhibits.

He is right to assert one general lesson about water management. He writes that it has never been solely a question of technology or science that can be solved within political borders. The unruliness of water means that the business of working with it is "deeply inflected with cultural values, with notions of justice, with ideas and fears about nature and climate". ■

Philip Ball *is a writer based in London, and the author of* The Water Kingdom: A Secret History of China.
e-mail: p.ball@btinternet.com

LAB LIFE

Science in hand: how craft informs lab work

Artists and performers can enrich the physical act of experimentation, explain **Roger Kneebone**, **Claudia Schlegel** and **Alan Spivey**.

Even shaking a sample, rather than stirring it, can change results. Why then, among the many reasons discussed for the reproducibility crisis, does lab practice not get more attention (see *Nature* **533**, 452–454; 2016)?

Most science students enter university with years of screen time under their belts, but very little experimental experience. Indeed, many early-stage PhD students struggle with the transition from predetermined practicals to independent experimentation and design, where the ability to notice tiny departures from the expected might be crucial to discovery.

Some might not have 'good hands'. Moreover, written accounts are notoriously open to interpretation: 'add reagent X dropwise until the solution changes from red to yellow' seethes with potential ambiguity. Laboratory knowing takes place at the intersection between materials, tools and a researcher's body. Its rhythms differ from those of simply absorbing facts.

We — a surgeon, a research nurse and a synthetic chemist — looked beyond science to discover how people steeped in artistic skills might help to close this 'haptic gap', the deficit in skills of touch and object manipulation. We have found that craftspeople and performers can work fruitfully alongside scientists to address some of the challenges. We have also discovered striking similarities between the observational skills of an entomologist and an analytical chemist; the dexterity of a jeweller and a microsurgeon; the bodily awareness of a dancer and a space scientist; and the creative skills of a scientific glassblower, a reconstructive surgeon, a potter and a chef.

For more than 20 years, R.K. has explored this landscape, building a network of experts from apparently unconnected domains to share insights for the lab or operating theatre. In October last year, that multidimensional collaboration led to the Art of Performing Science, a symposium at Imperial College


The Art of Performing Science symposium at Imperial College London. L–R: Curator Miranda Lowe works with taxidermist Derek Frampton; letter cutter Phil Surey with plastic surgeon Haz Saddeen; and semiotics scholar Gunther Kress with technician Paul Brown and space scientist Kathrin Altwegg.

FERGUS BURNETT/IMPERIAL COLLEGE LONDON

London — funded by the UK Economic and Social Research Council — that has proved to be a powerful catalyst for further collaboration.

It was an intensely diverse grouping, drawing together more than 60 experts from Britain and the rest of Europe. Here were synthetic chemists, biologists, paediatric surgeons, radiologists, scientific glassblowers and instrument technicians; and social scientists from anthropologists to ethnographers. Here, too, were curators, keepers and conservators from major UK institutions, including London's National Gallery and Victoria and Albert Museum; potters, taxidermists and stonecutters; and performers including musicians and dancers, as well as chefs and even an Olympic rower.

Unexpected parallels in practice emerged. Kathrin Altwegg, leader of the ROSINA instrument programme for the European Space Agency's ROSETTA comet probe, and Imperial technician Paul Brown (who works on the agency's 2020 Solar Orbiter initiative) revealed how space programmes demand close collaboration between experts in their disciplines. Ophthalmic anaesthetist Friedrich Lersch described how his fingers must 'see' layers of the eye to ensure that he finds the right plane for injection. He revealed that his past experience as an apprentice tailor has enabled the interpretation of subtle signals from materials. Conservators Charlotte Hubbard and Isabella Kocum found common ground with taxidermist Derek Frampton and dentist Flora Smyth Zahra; all must manipulate probes and forceps to restore fragile materials. Detailed observation and fine hand–eye coordination are centrally important in the lab, conservation room and artisan's studio.

Better still, 12 months on, some of these encounters have led to practical solutions. Letter-carver Phil Surey and consultant hand surgeon Samantha Gallivan discovered a shared gestural language: both use chisels with hard materials, 'listening' to stone or bone as they make irreversible cuts with focused precision. Carvers, for instance, notice that when stone 'gets tired' through repeated hammering, it is at risk of fragmenting. Gallivan and fellow orthopaedic surgeon Malek Racy are now collaborating with stone-carver Nina Bilbey to find a way of developing such skills early in surgical training.

> ***"Laboratory knowing takes place at the intersection between materials, tools and a researcher's body."***

The parallels between chemistry and cooking were especially striking. Jozef Youssef — chef patron of London-based experimental gastronomical design studio Kitchen Theory — highlighted *mise en place*. This central culinary principle demands that each cook manage their own work space — knives here, ingredients there — to ensure that they can replicate dishes in the demanding setting of high-end restaurants. In labs, similar ways of working are expected but seldom articulated.

R.K., A.S. and Youssef have now launched the Chemical Kitchen, a three-year collaboration between chemistry and culinary students that will start in January 2019. Through a programme of graded tasks, undergraduate chemistry students at Imperial will experience the planning and precision of a professional kitchen. Whether making a soufflé or baking bread, ingredients must be weighed, combined and transformed through heat and pressure, every element rigorously controlled. Would-be chefs, in turn, will practise chemical procedures requiring similar precision, such as distillation or using a Schlenk vacuum line cooled to −50 °C to reproducibly form air-sensitive organometallic compounds. The aim is reciprocal illumination.

Systematic working, close noticing, dexterity, meticulousness and respect for materials and fellow workers all lie at the heart of successful, reproducible science. By examining laboratory 'doing' from unfamiliar perspectives, scientists could shed new light on — and hopefully begin to overcome — the reproducibility crisis. ■

Roger Kneebone, *a trauma surgeon and general practitioner by background, is professor of surgical education and engagement science at Imperial College London.* **Claudia Schlegel** *is head of the Skillslab at the Bern College of Higher Education of Nursing in Switzerland.* **Alan Spivey** *is a synthetic organic chemist trained in Nottingham, Oxford, Geneva and Cambridge, and now a professor at Imperial College London.*
e-mail: r.kneebone@imperial.ac.uk