CAVENDISH LAB./UNIV. CAMBRIDGE

Ernest Rutherford (right) and Jack Ratcliffe in the Cavendish Laboratory in 1932.

PHYSICS

Crucible of science

Graham Farmelo ponders Malcolm Longair's study of the Cavendish, a physics laboratory with few rivals.

Physics laboratories are a relatively recent innovation. They started to spring up 150 years ago, centuries after investigators began trying to understand the inanimate world using observation and rational thought. Chemists were ahead of the game — their first laboratories appeared a quarter of a millennium earlier (D. Lowe *Nature* **521**, 422; 2015).

In 1927, Ernest Rutherford spoke at the opening of the H. H. Wills Physics Laboratory at the University of Bristol, UK. He said: "Our pure science laboratories should in the main be set aside for fundamental

research." Those that did research relating to industry should be funded by the government or manufacturers, in places "where the research workers can come into close contact with manufacturing conditions". Rutherford was at the time director of the Cavendish Laboratory at the University of Cambridge, UK — a world-leading institution for experimental physics. Today, his purism looks

**Maxwell's
Enduring Legacy:
A Scientific History
of the Cavendish
Laboratory**
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Press: 2016.

almost quaint, with most academic physics laboratories relying heavily on support from industry and other sources.

In what is patently a labour of love, the astronomer Malcolm Longair now gives us a comprehensive scientific history of the Cavendish in *Maxwell's Enduring Legacy*. Longair, who was the lab's head from 1997 to 2005, describes its inception well. Its early development in the 1870s, on a small site near the centre of town, was bankrolled by the university's chancellor, William Cavendish. He was among those who wanted to ensure that Cambridge could continue to supply top-notch graduates to help to administer the increasingly technological British Empire. Several sceptics, particularly among the champions of the prestigious natural-sciences course, the Tripos, argued that experimental training was unnecessary. The mathematician Isaac Todhunter wrote: "Experimentation is unnecessary for the student." He believed that "the student should be prepared to accept whatever the master told him".

The venture made an excellent start, Longair shows, when James Clerk Maxwell was appointed its first director. A strong mathematician with almost superhuman physical intuition, he was determined to nurture experimentation, and had extraordinarily wide interests. He was as eager to explore the new technology of wireless telegraphy as he was to master modern topological mathematics. After his death in 1879 at just 48, the university appointed as his successor John William Strutt, Lord Rayleigh, a versatile physicist who went on to discover argon and win a Nobel prize. Strutt's five years in the post consolidated the reputation of the lab. He was succeeded by theorist J. J. Thomson, who, although not a dexterous experimenter, discovered the electron at his bench there in 1897. With Thomson at the helm, the Cavendish rivalled the mighty Imperial Physical Technical Institute in Berlin as the world's pre-eminent centre for experimental physics.

The next director, Rutherford, died unexpectedly in 1937 after a botched operation. In the quest to find his successor, Longair says, the crystallographer Lawrence Bragg was the "obvious choice". This surprised me. In 1992, theoretical physicist Rudolf Peierls, who knew the lab well, told me that Rutherford's deputy James Chadwick (discoverer of the neutron) was the widely tipped successor, and that the failure to appoint him led to "a minor scandal". Either way, Bragg proved a far-sighted leader, and his promotion of crystallography yielded impressive results. Notably, Francis Crick and James Watson gave the Cavendish one of its greatest triumphs by identifying the structure of DNA in 1953.

The quantum theorist Nevill Mott, appointed director in 1954, continued the policy of diversification and expansion. Teaching and research activity doubled, ▶

► and the lab's Radio Astronomy Group, led by Martin Ryle, had a series of successes, most famously the discovery of pulsars by Jocelyn Bell Burnell in 1967, working with her supervisor Antony Hewish (A. Hewish *et al.* *Nature* **217**, 709–713; 1968). By this time, the Cavendish was so large that its director was not so much a powerful commander-in-chief as chair of a company, as Longair aptly describes it.

The lab's research had outgrown its space: the number working there had risen from around a dozen in the 1870s to some 40 times that number. In 1973, the next director, Brian Pippard, moved the Cavendish to much larger premises in West Cambridge, the workplace of about 1,000 people. Longair chronicles this move and presents the achievements of Pippard and his successors as Cavendish Professor of Physics, Sam Edwards and Richard Friend, with detail that will satisfy the most assiduous reader of annual reports. The breadth and depth of the areas of physics now being explored by the laboratory are remarkable: all its previous specialities, as well as everything from optoelectronics to medical physics, thin-film magnetism and the physics that underlies studies of the sustainability of the global economy.

Longair's history is in the form of a well-organized modern physics book, most of its 22 sections replete with charts, tables and lucid technical explanations presented neatly in boxes. Abundant diagrams, photographs, line drawings, floor-plans and facsimiles of historical documents give fascinating insights into the lab's development. Very much the account of an insider, the book would have benefited from a wider international perspective.

It would also have been interesting to hear more about the challenges that the lab faces to preserve its eminence. Rutherford kept an eye on almost every research project — no longer feasible for even the most energetic director — and took personal responsibility for keeping his fiefdom fleet of foot so that it could respond quickly to developments. The main challenge of directing the laboratory today, I imagine, is to ensure that the elephant can keep dancing. ■

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MEDICAL RESEARCH

Citizen medicine

Sally Frampton and Sally Shuttleworth explore a show on public involvement in the evolution of vaccination.

The introduction of vaccination in the late eighteenth century is often viewed as a defining moment, when modern medicine began to stem the ravages of disease. But it has not just been down to pioneering doctors: members of the public have been significant in shaping the development of vaccination, both as practitioners and as critics. *Vaccination: Medicine and the Masses*, an exhibition at the Royal College of Surgeons' Hunterian Museum in London, seeks to unravel those threads with photographs, letters, pamphlets, specimens and medical devices.

The exhibition is part of Constructing Scientific Communities (<http://conscicom.org>), a project on citizen science past and present for which we are researcher (S.F.) and principal investigator (S.S.). In 1798, physician Edward Jenner published *An Inquiry into the Causes and Effects of the Variolæ Vaccinæ* (a draft manuscript features in the exhibition). It showed that protection from the deadly, disfiguring disease smallpox could be conferred by exposure to the much milder cowpox. Jenner's experiments convinced fellow medics, but were themselves inspired by the observations of farming communities in south-west England that milkmaids (prone to cowpox infection, acquired by handling the udders of infected animals) hardly ever caught smallpox.

Local knowledge and volunteers remain key to successful vaccination programmes. The Global Polio Eradication Initiative, for example, has involved more than 20 million volunteers since it began in 1988, many working in dangerous conditions (H. J. Larson and I. Ghinai *Nature* **473**, 446–447; 2011). One story highlighted in the exhibition focuses on Ali Maow Maalin, the Somali cook who was the last person to be infected with naturally occurring smallpox. After he recovered, Maalin campaigned for polio eradication. He died of malaria in 2013, while carrying out polio vaccinations.

But public resistance has also dogged vaccination, as the exhibition makes clear. In the nineteenth and twentieth

Vaccination: Medicine and the Masses
Hunterian Museum,
London.
Until 17 September
2016.

centuries, pamphlets from Britain's National Anti-Vaccination League and others played on fears that the procedure poisoned children's blood and

laid them open to a host of diseases. Resistance grew to the British government's compulsory smallpox-vaccination programme, established in 1853. By 1907, the programme was effectively abolished.

The diseases have changed, but scepticism remains dangerous — not least because of the lingering impact of Andrew Wakefield's discredited work hinting at a link between the measles, mumps and rubella (MMR) jab and autism, published almost 20 years ago. US and UK outbreaks of measles in recent years have had a strong correlation with vaccine refusal.

As highlighted by Constructing Scientific Communities, citizen science now benefits from digital platforms such as Zooniverse, which enable projects that range from identifying galaxies to analysing cancer cells. That potential makes it timely now to look back to when barriers between professional and amateur science had not yet been erected. Researchers are looking, for instance, at mass involvement in Victorian public-health movements such as the drive to stop air and water pollution, and at the local natural-history groups whose records still serve as benchmarks. With Zooniverse, we are creating projects drawing on historical records of the era: *Diagnosis London*, for instance, will enable people to analyse reports of the nineteenth-century Medical Officers of Health for London.

Like *Vaccination*, these projects offer fascinating insights into the lives of people faced with an array of public-health challenges, and into the medical science that is running to keep up with them. ■

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A nineteenth-century 'shield', used to protect vaccination sites.