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Viewpoint

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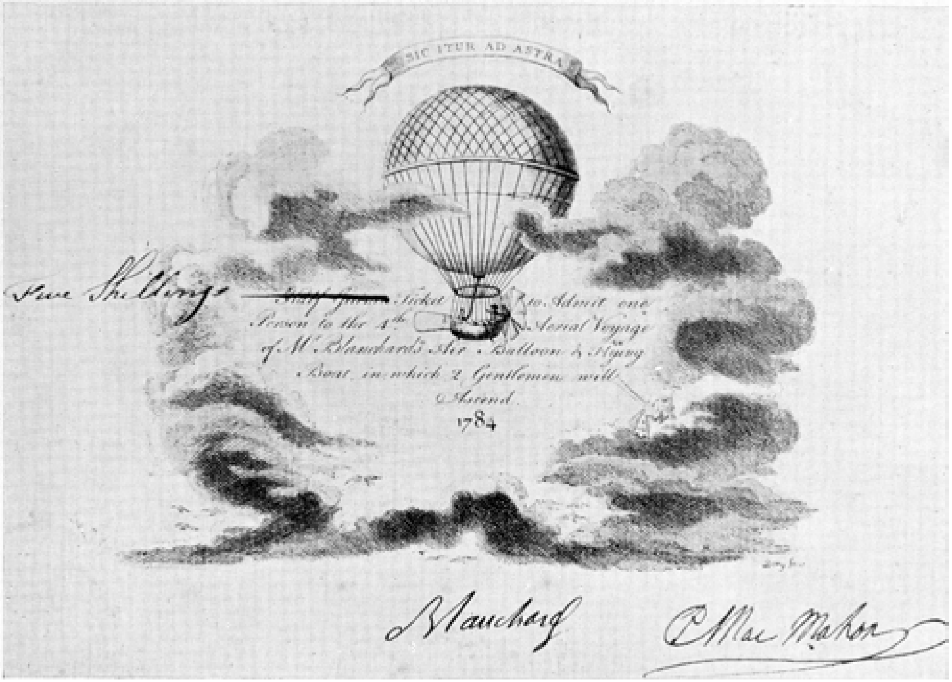


Signed admission ticket for Blanchard Balloon ascent from Chelsea, October 16, 1784. Courtesy of the Wellcome Library, London.

Editorial

As many of us head off on conferences or holidays this June, this issue of *Viewpoint* roams far and wide on the topic of travel.

A feature by Caitlín Doherty notes the challenges and opportunities of vertical travel in the 18th century (1-2). Marionne Cronin reflects on how polar travellers wrapped up warm with under-explored pieces of kit (4-5), and Erin Beeston also highlights neglected technologies in her discussion of freight rail (10-11). Katherine McAlpine's article on maritime timepieces explores historical travel necessities (3).

Geographical curiosities are covered by Cristiano Turbil's article on how Darwin's ideas circulated the globe (9) and by Dmitry Shcheglov's piece on Ptomley's maps (8-9). Metaphorical movements are discussed by Anne M. Thell on brains in early modern science writing (12-13) and Richard Bellon writes on bringing science back home (11-12).

Also featured are reports on the promotion of family friendly history of science by Laura Hobbs and on a fascinating 20th century statistician by Jochen F. Mayer (6-7).

Contributions to the next issue should be sent to viewpoint@bshs.org.uk by 15th August 2015

Alice White, Editor

Up and Away! 18th Century Science of Ballooning

Caitlín Doherty on the lofty ambitions of 18th century balloonists

Distance travelled is usually measured along a horizontal axis, but for a group of natural philosophers, showmen, and members of a rapt public audience at the end of the eighteenth century, vertical movement was a far more exciting prospect.

The invention of balloons capable of carrying human weight (and at first the weights of various farmyard animals) took place in France during the year 1783. First the Montgolfier brothers created a linen sack, which they inflated with noxious smokes in the fields of Annonay. They then repeated this at the Tuileries gardens in Paris before a royal audience. Shortly after, Jacques Charles and the Robert brothers pioneered the use of hydrogen as a much safer (and less fragrant) lifting agent for aerostats, and balloons became a popular European phenomenon. So goes the traditional history of humankind's first experience of flight. The balloon has since become a symbol of Enlightenment thought and culture, representative of an early-Romantic escape from the limits of the Earth, especially in France and Britain. This view, however, is one derived from the terrestrial position of watching a balloon rise. To begin to understand the complex and multiple roles of balloons in this period, it's necessary to take an imaginative step inside the basket of an aerostat. This reveals that although the balloon was itself the product of a series of natural philosophical inquiries into the nature of gases, it was also a site of knowledge production. In Britain, during the final 15 years of the 18th century, the hydrogen balloon observed from the ground seemed a levitating testimony to mankind's genius. For the aeronaut above, however, a dangerous and unpredictable experimental journey was in progress.

The reputation of balloons as scientific instruments suffered early on from association with insubstantial properties of airs and gases, and from balloons' popularity among the general public. To rectify some of the discredit poured upon them – notably by men such as Joseph Banks – those who fashioned themselves as aerial pioneers took two approaches:

firstly, the formation of a literary mode meant to convey the emotional and aesthetic intensity of the experience of flight; secondly, detailed scientific records of the environmental and physical phenomena encountered on the flights. Though I have divided these approaches into separate categories, for the writers of aeronautical accounts there existed no such distinction. Thus within the space of a page in Thomas Baldwin's account of a flight over Chester in 1785, one reads:

> *The Fluctuation of the Barometer he imagined to arise from continued exertions of the Gas within the Balloon, opposed by the atmospheric Air, which varying in Density and Temperature would give an unequal Resistance to the Balloon … But what Scenes of Grandeur and Beauty! A Tear of pure Delight flashed in his Eye! of pure and exquisite Delight and Rapture; to look down on the unexpected Change already wrought in the Works of Art and Nature, contracted to a Span by the NEW PERSPECTIVE*
>
> Baldwin, *Airopaidia*, Chester, 1786, p.36

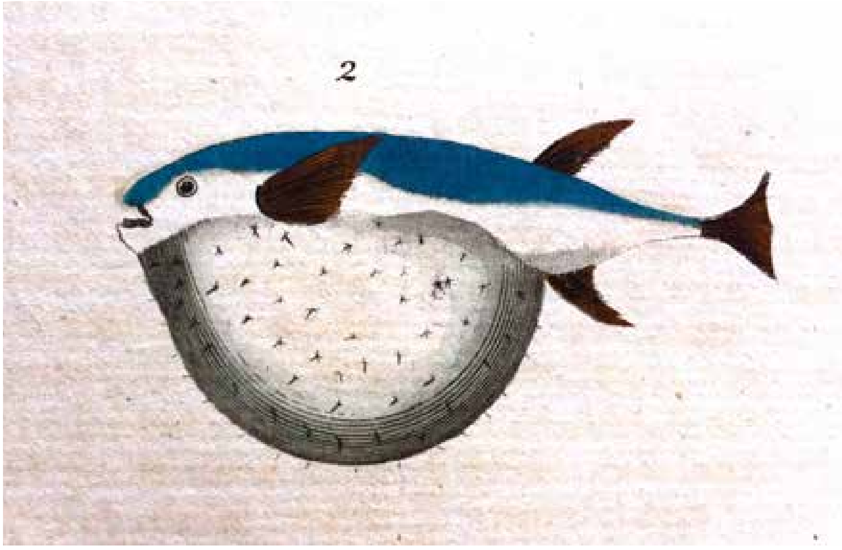
This juxtaposition of sterile observation and emotional rapture might strike us as strange, but is in keeping with contemporary philosophical ideas, such as Edmund Burke's theory of the sublime as a human response natural phenomena, and David Hume's attempt to outline a Science of Man. To experience the emotional side of balloon flight in the socially correct fashion required an education in the natural sciences.

One literary trope in accounts of early aerial voyages is the inclusion of a list of recommended equipment for the flight. While this may seem like helpful advice to the would-be balloonist, these litanies can also be read as didactic exclusions and invitations: if you do not know how to read a barometer, do not bother flying! These experiences are marvellously serious affairs, not to be undertaken "lightly". Baldwin gives us two pages and twenty points of precise recommendations and includes an exclusive warning,

> *The following Inventory, with which he [Baldwin] ascended, may be of Use to future Aironauts; to whom only it is addressed.*
>
> Baldwin, p.9

The contrast in styles in Baldwin's writing also reinforces a central conflict in the use of balloons in their earliest years in Britain: no one could decide whether the balloon was the subject or the product of scientific investigation. Balloon flights were both experiments in themselves, and sites of experimental behaviour.

Preparing a balloon for flight required great wealth. In 1784 the American physician John Jeffries paid the professional aeronaut Jean-Pierre Blanchard the enormous sum of one hundred guineas just to be taken aloft as a passenger. From the amount of silk necessary to construct a balloon, to the *gomme* with which it had to be coated to prevent gas leaks, to the costly production of hydrogen required for inflation, aerostatic flight was a matter of wealth beyond most individuals' means. Groups such as the Royal Society were unwilling to fund aerial travel until the philosophical merit of flight had been established, but to do this aeronauts had themselves to appeal to the public for the money. Subscription services were set up, with tiered ticketing systems (see cover image). Pay more, and you would gain access to behind-the-scenes secrets of hydrogen manufacture, and balloon inflation. Pay nothing, and you would be excluded from understanding the rational causes of balloon-flight, left in the urban crowds to crane your neck and watch the aerostat vanish behind the clouds.



'GLOBE DIODON FISH' from A new dictionary of natural history, *W.F. Martyn (1785), held at the Zoological Library, University of Cambridge. Photograph by Caitlín Doherty*

Tensions arose rapidly in Britain between those who saw ballooning as both an end in itself, and a means to live by, and those who wished to utilise the balloon to increase human knowledge, particularly about the atmosphere. Although they flew together twice, the relationship between Blanchard and Jeffries was famously strained, in part due to their different aims as aeronauts. While Jeffries saw balloon experiments as his way into membership of the Royal Society, Blanchard was already cultivating an image as a professional aeronaut. The character of Jeffries is revealed to us through his self-presentation in a portrait by John Russell: ownership of instruments was so important to him that he is depicted caressing his barometer in the portrait. But he is also dressed extravagantly for flight, in leopard skin hat and gloves. Scientific endeavour is combined with the glamour of dangerous exploration.

One major problem for both the performative and the philosophical balloonists was the infancy of atmospheric chemistry and meteorology at the time. The ascent and descent of the balloon could, in good circumstances, be reliably influenced by ballast, and release of hydrogen via a valve in the balloon, but no one could make a balloon travel from one location on the earth to another with any predictable success. It was generally assumed that the solution must lie in parallels between movement through the air and movement on water, so that aeronauts such as Blanchard experimented with oars for rowing the balloon in the required direction. Samuel Hoole took the air-water parallel to the extreme, by suggesting that balloons should be modelled on a certain species of newly-discovered pufferfish that could inflate at will, meaning balloonists would be able to navigate the aerial ocean like fish out of water. The first writer to theorise the production and history of balloons, Tiberius Cavallo, gave credit to their use as exploratory vehicles with which aerial currents could be mapped,

> *Indeed it is not known that those different currents always exist; but it is not unlikely that they, as has been the case with the currents of various seas, may be better ascertained by future experience and investigation; and we have now in our power the means of examining them at any time.*
>
> Tiberius Cavallo, *The History and Practice of Aerostation* (London, 1785), p.193

Though our modern view of balloon-flight is one of calmness, solitude and Romantic contemplation, the reality of flight for 18th century aeronauts was fraught with danger and tension. Before balloons became a method of viewing the landscape, they were vehicles with which to investigate the skies.

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Travels with a Trusty Friend

Katherine McAlpine discusses the tests and travels of an important timepiece.

The official portrait of Captain James Cook painted by Nathaniel Dance, and the K1 seawatch. Images courtesy of the National Maritime Museum.

Those of us who have ever tried to read a map in an unfamiliar city or ask for directions in broken Spanish will agree that it can be better to have someone travelling with you who can help in such situations, who maybe has superior orienteering or language skills, to help you find your way through the unknown terrain. For Captain James Cook, that friend was not a person with superior linguistic or orienteering skills (or even someone kind enough to turn on the data roaming on their phone), but a watch.

In 1772, Captain James Cook embarked on his second voyage of discovery to chart the unknown Southern Continent. He had already completed one voyage of discovery, which had a multitude of missions to accomplish. The initial impetus for the mission had come from the Royal Society, who petitioned the Admiralty to fund a voyage to Tahiti to observe the transit of Venus in 1769. Cook and his crew had also been given the confidential mission of attempting to establish the existence of a Southern Continent.

The voyage also provided an opportunity to test the lunar distance method of finding one's longitude at sea. Cook had been selected for this voyage based on his existing navigational ability, and on top of the lunar distance method he used traditional navigational methods such as dead reckoning, as well as taking advantage of local knowledge. The lunar distance method required using instruments such as sextants to make astronomical observations of the moon's position relative to the stars, and a series of calculations. The creation of a yearly Nautical Almanac was intended to relieve seamen from the need to do long, onerous calculations based on their observations. However, with only the 1768 and 1769 Nautical Almanacs available, Cook was required to do the onerous calculations himself.

By the time of Cook's second voyage, the second generation of longitude timekeepers were ready. John Harrison's marine timekeeper, H4, had performed well on its test voyage to Barbados, but with only one, very expensive, timekeeper in existence, questions over its long-term value remained. By 1771, Larcum Kendall's first copy of Harrison's seawatch, K1, was ready to be trialled at sea and at the suggestion of Astronomer Royal Nevil Maskelyne, it went with Cook on his second voyage. K1 was not the only timekeeper on-board this voyage: it was accompanied by three other marine timekeepers made by London clockmaker John Arnold.

This voyage saw K1, along with Cook and his crew, make the arduous journey through Antarctic ice on ships *Resolution* and *Adventure*. X-rays of Hodge's painting 'View in Pickersgill Harbour, Dusky Bay, New Zealand' reveals Hodge's attempts to capture the extreme Antarctic conditions. Underneath Hodge's sumptuous, sublime composition of Dusky Bay, the X-rays revealed two icebergs, the one on the left matching a drawing the voyage naturalist George Forster and a description by voyage Astronomer William Wales. Wales describes the iceberg as 'like 'an old square castle, one end of which had fallen into Ruins, and it had a Hole quite through it whose roof so exactly resembled the Gothic arch of an old Postern Gateway that I believe it would have puzzled an Architect to have built it truer'.

After the ice, they arrived in New Zealand on 11 April 1773 in what became Pickergsill harbour, named for Lieutenant Richard Pickersgill who observed that it would be a good place to anchor, thanks to the deep water close in to the shore. This composition can be seen in the Hodge's painting, overlaying the icebergs. In the painting, a clearing can be seen through the trees where voyage astronomers William Wales and William Bayly had pitched their observing tents. The Astronomers were to oversee the trials of K1 and the Arnold timekeepers and this included keeping the watches running, monitoring performance and monitoring performance against dead reckoning, lunar distance and other astronomical observations. Although the Arnold watches did not perform so well (possibly scuppered by Bayly's failure to wind them on one occasion), K1 passed its test with flying colours. Cook came to refer to it as his 'trusty friend' and 'never failing guide'. By the homeward stretch, Cook was using it to chart his course to St Helena.

K1 joined Cook once more on his third voyage of discovery, to find the North-West passage. This voyage saw them visit Hawaii, where Cook ultimately met his end in 1779. In 1786, K1 was passed to Captain Arthur Philip, of the HMS Sirius, who had been tasked with establishing a colony in Australia. It was nearly lost forever after the *Sirius* was wrecked on Norfolk Island in March 1790, but was removed from the ship before it sank. It then travelled with John Jervis to the West Indies at the start of the French Revolutionary War, before being returned and withdrawn from service in 1802. Today K1 is kept in the collections at the National Maritime Museum.

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Sourcing the Technologies of Polar Travel

Marionne Cronin discusses the intriguing origins of the kit used for early polar expeditions

Polar technologies in action: (L-R) George Noville, Richard Byrd, and Floyd Bennet at King's Bay, Spitsbergen, May 1926 Source: Byrd Polar Research Center Archival Program, Box 214, Folder 7742

In the archives of the Byrd Polar and Climate Research Centre in Columbus, Ohio, there is a photograph of three men posing in front of an aeroplane's open cabin door. The men gaze intently into the camera, dressed in fur parkas that, along with the snow on the ground, suggest their Arctic location at King's Bay (Ny-Ålesund) on the island of Spitsbergen.

In its composition the image echoes so many other photographs of polar exploration, with the exception that an aeroplane, not a ship, forms the backdrop. Knowing what came next - that on 9 May 1926, American naval aviator Richard Byrd and his co-pilot Floyd Bennett would return from a flight of just under 16 hours and claim to have become the first men to reach the North Pole by air; that Byrd would return home to a rapturous reception; and that he would be hailed as a popular hero in light of his flight to the top of the world - knowing all this, the photograph initially appears to be simply another iteration of these existing images of heroic polar exploration. But notwithstanding its apparent simplicity, this picture in fact holds clues to another story, one that has the potential to challenge dominant preconceptions about the role of gender and indigenous people in the history of 20th-century polar expeditions.

Although his claims would subsequently become the subject of controversy, in 1926 Byrd was hailed in the American press as a national hero, returning to a boisterous New York welcome complete with military escort and tickertape parade. He would receive a Congressional Medal of Honor and would be distinguished by organisations as varied as the National Geographic Society, the Royal Aero Club, and Yale University. The popular culture produced through these celebrations contained an interesting blend of nostalgic and modernist rhetoric. Some narratives presented Byrd as heir to a romantic tradition of polar exploration in which heroic fur-clad explorers battled their way to the Pole over treacherous ice. Simultaneously, other accounts exalted his flight as a triumph of modern mechanical progress, extolling the aircraft's ability to compress polar space and time. In particular, comparisons between Byrd's 16-hour flight and Robert Peary's 429-day journey to the North Pole by dog sled in 1909 were used, in President Coolidge's words, as 'a striking illustration of the scientific and mechanical progress [achieved] since the year 1909' ('Capital Gives Ovation,' *New York Times*, 24 June 1926). Within these narratives, the combined triumph of man and machine became a symbol of the entire nation's technological modernity.

These accounts of modern progress deployed images of circumpolar peoples and technologies as markers of a bygone era, one that would be left behind by a new breed of modern explorers soaring through the skies in their powerful machines. This comparison reflected a broader interwar culture of adventurous, motorized exploration that was connected to the practice of salvage anthropology. In these expeditions, explorers sought out supposedly untouched, primitive indigenous people, who they depicted as the vanishing representatives of the modern world's last frontier. Within expedition narratives, these people were used to create a picturesque backdrop for the modern explorers' frontier adventures. These sorts of images contributed to a particular history of exploration in which Euro-American male explorers functioned as the central mobile actors and as carriers of modernity, while the people whose territories they entered were framed as static and vanishing.

These representations sought to draw a sharp distinction between the modernity of Byrd's flight and the primitive technologies of a timeless Arctic. This photograph, however, offers evidence that this boundary was not as clear-cut as these narratives might suggest. At the heart of the image, carried on the explorers' bodies, appear another set of technologies: reindeer-skin and fur parkas and trousers, sealskin mittens, and reindeer-skin boots. Notwithstanding their function as rhetorical symbols linking Byrd to the romantic tradition of heroic exploration, these garments were key components of the expedition's equipment. Not only would they keep the aviators warm during their flight, they would become essential pieces of the fliers' survival kit in the event of an emergency landing. Indeed, Byrd himself saw the clothing as so essential that he was prepared to delay the expedition's departure in order to obtain it.

But where did it come from? In amongst Byrd's voluminous expedition-planning correspondence (located in the Papers of Admiral Richard E. Byrd, Byrd Polar and Climate Research Centre Archival Program, The Ohio State University) there are a handful of letters and telegrams indicating that, although the apparel was sourced through the Lomen Reindeer Corporation in Nome, Alaska, the Lomens in turn relied on the skill and labour of local Iñupiaq women to produce these garments. Thus, the clothing in the photograph bears witness to another history of the technologies of exploration.

Historians have acknowledged indigenous women's important roles in exploration during earlier eras, but archival records often offer only scanty details of their contributions. The same is true of Byrd's expedition. Unlike the manufacturers of Byrd's plane, for example, these women are largely invisible in both the archival and public record of Byrd's flight. Byrd, for instance, made no mention of these women in his public appearances and newspaper reports merely referred to the clothing as 'made in Alaska under the direction of the Lomen family' ('Byrd Ship Ready to Sail Tomorrow,' *New York Times*, 4 April 1926). Museum and archival collections of expedition-related garments thus offer potential alternative source material and tracing the objects' life-histories affords exciting opportunities to gain a better understanding of these often overlooked histories.

Studies of circumpolar skin clothing have demonstrated that these garments are highly-developed technologies that reflect the extensive systems of interlocking skills and expertise involved in their production and maintenance. Moreover, the knowledge and techniques employed are primarily (though not exclusively) women's skills and expertise. With this in mind, the photograph of these parka-clad men becomes much more than simply part of a narrative of heroic mechanized exploration. Instead it demonstrates that, even in an era when aviation seemed to detach exploration from the indigenous labour that had supported earlier polar expeditions, indigenous women's knowledge, labour, and technical expertise remained essential to 20th-century exploration practices.

As these parkas illustrate, attending to the expedition's material culture can provide evidence of the participation of people whose presence is largely camouflaged in narratives of 20th-century exploration. At the same time, women's central roles in creating these garments, which were seen as essential to the flight's success, contest depictions of these aerial expeditions as purely masculine affairs. Furthermore, these objects' histories challenge assumptions that the circumpolar world and its peoples exist on the margins of modern histories of technology. Instead, the objects' movement from northern Alaska to New York and on to Spitsbergen demonstrates that northerners were both entangled and active participants in these histories.

Looking again at the photograph and seeing now, not just the three men and their plane, but the parkas, mukluks, and mittens and the women who made them prompts the questions: What stories might reveal themselves if we looked again at the technologies of scientific travel? What histories might we begin to hear?

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BSHS Notices

BSHS Annual Conference

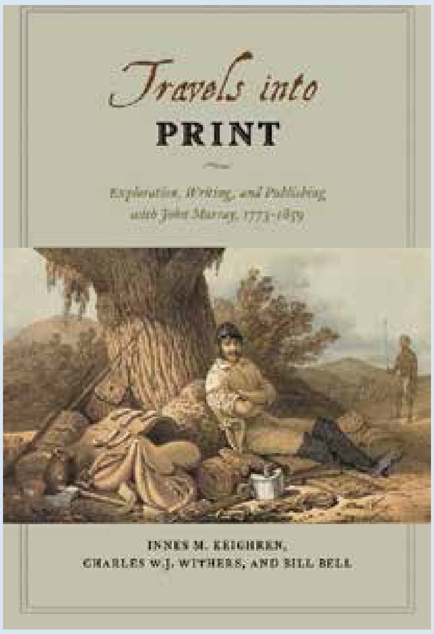
The BSHS Annual Conference will be held in Swansea, 2-5 July. Don't forget to apply for Butler-Eyles Travel Grants beforehand: www.bshs.org.uk/grants/butler-eyles-travel-grants

Changes to BJHS Reviews

Dr Don Leggett, Nazarbayev University, will be succeeding Dr Adam Mosley as the Reviews Editor for the *British Journal for the History of Science*. We would like to offer our thanks to Adam for all his hard work, and welcome Don to the role.

Changes to the BSHS Website

As this issue of *Viewpoint* was going to press, the BSHS was on the verge of releasing a revamped version of its website, at www.bshs.org.uk We'd love to have your comments and suggestions on the new look! Please send these to the Executive Secretary, Lucy Tetlow, at execsec@bshs.org.uk



Book Competition

In the 18th and 19th centuries, books of travel and exploration were much more than simply the printed experiences of intrepid authors. They were works of artistry and industry—products of the complex and often contentious relationships between authors, editors, publishers, and printers. In Britain, there was no publisher more renowned for its travel and exploration books than John Murray.

Travels into Print: Exploration, Writing, and Publishing with John Murray, 1773–1859, published by the University of Chicago Press, considers how journeys of exploration became published accounts, and how travellers and explorers sought to demonstrate the faithfulness of their written testimony and to secure their personal credibility. *Travels into Print* takes the modern reader on a journey into the nature of exploration, the production of authority in published travel narratives, and the creation of geographical and scientific authorship. Through its attention to travel in the service of science, the book offers new insight into the nature of field science and how travelling scientists sought credibility through methodology and rhetoric.

For a chance to win a copy of *Travels into Print*, email nlilly@uchicago.edu with your answer to the following question by 1 August 2015.

Which of the following travelling scientists did not publish a book with John Murray?

(a) Charles Darwin
(b) Charles Lyell
(c) Alfred Russel Wallace

One correct winner will be chosen at random.

BSHS Grant Reports

Spies, Sight, Splints & Snow: Family Friendly History of Science, Technology & Medicine

Laura Hobbs on how a BSHS grant facilitated family learning about WWI science

Science from the Start provides and promotes informal science learning opportunities for families, including under 5s who are often deemed too young for such endeavours. With the support of a BSHS Outreach and Education Committee Project Grant, *Science from the Start* has been able to provide several family activity sessions and information displays based around a poster about science, technology and medicine in World War I. Printing of the poster, travel to the first activity session and the majority of activity materials were funded by the BSHS Outreach and Education Committee Project Grant.

The poster was pitched broadly at primary school aged children, and the associated activities were suitable for children aged from birth up. The three topics (science, technology and medicine) each had a section on the poster and an accompanying activity. These were supported by an information sheet detailing what to do, how the activity was linked to World War I, and a brief explanation of the underlying science so that parents/carers could lead and facilitate learning for their own children. Activities were designed to facilitate adult engagement too, so that the learning was a family experience.

Use and development of scientific knowledge in World War I was demonstrated through the story of invisible ink messaging. Mabel Elliott uncovered lemon juice messages through her knowledge of chemistry. Subsequent invisible ink recipes became more and more complex and were only made public by the CIA in 2011. To explore this during the activity sessions, children wrote their own messages with lemon juice, revealing the writing with heat once the juice had dried.

Periscopic technology was used in the trenches to enable soldiers to look over the top without being shot at. As well as thinking about the implications of having to use mirrors to look above ground because the alternative was just too dangerous, families investigated mirrors and light by making their own periscopes and using them to look around corners or over tables.

Advancements in medicine were represented by the example of the Thomas splint, which, after its introduction in 1916, dramatically reduced the mortality rate for soldiers suffering a broken femur. Attendees used dolls with soft limbs, bandages and lollipop sticks to investigate how the extra support provided by the Thomas splint had such a significant impact on treating these injuries.

The Science from the Start poster and children enjoying a pretend mud activity. Images courtesy of Laura Hobbs.

In addition, younger children in particular were catered for with sensory activities: a sensory bin, snow dough and pretend mud (these were enjoyed by older children and adults too!). The sensory bin contained items relating to the three activities described above, for example mirrors, lemons, bandages, lollipop sticks and sensory bottles containing reflective items. Snow dough is made from cornflour, oil and glitter, and compacts and crumbles in a similar way to snow. The mud was made by mixing together water, flour and brown paint. These activities were also accompanied by information sheets as described above, linking to the examples on the poster and explaining how mud and snow contributed to difficult conditions in the trenches.

As well as three activity sessions in Lancashire, the poster was also displayed for several weeks in libraries in Lancashire and Worcestershire. This enabled it to be viewed by other people outside the activity sessions, including those not accompanied by children – the total reach of the activity sessions and poster displays to date is around 250 people. The first poster display and activity session were timed to coincide with Armistice Day and other related events, while the later sessions were able to build on the learning that took place in schools and other settings during that time. The poster is a durable resource that can be used for years to come, both alone and alongside the associated activities that were designed to accompany it.

The children attending the sessions were aged between 2 and 9 years, all accompanied by at least one parent or carer. Feedback indicated that both children and adults enjoyed reading the poster and doing the activities, often learning something from them, and that the activities greatly enhanced adult and child engagement above that with the poster alone. The opportunity to participate in hands on, practical activities helped children to think more clearly about conditions in the trenches, the roles science, technology and medicine played in World War I and how knowledge and techniques developed. Learning about the underlying science involved in war happened naturally within the historical context.

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Measuring the Uncountable? The Curious Career of Paul Flaskämper

Jochen F. Mayer reports on his research into a 20th Century philosopher, botanist and statistician.

Paul Flaskämper (1886-1979) was a complicated creature, and a BSHS grant has made possible an exploration of his curious intellectual trajectory. Archival traces of Flaskämper's life are spread across archives in Frankfurt, Heidelberg and Berlin, and before his concern for a genuine social statistical methodology, he traversed scholarly fields as diverse as 19th century natural philosophy of life, plant morphology, racial hygiene, and Neo-Kantian philosophy. This somewhat astounding intellectual spread raises complex questions about the relationship between both allegedly "acausal" and speculative holism, and more "causal" and "coherent" mathematical styles of thought commonly associated with quantitative sciences and statistics.

When the spectre of mathematisation haunted early 20th century sciences, opposition was particularly strong from German statisticians. 'German individuals do not sum', as Norton Wise once put it; statistics in Germany were more concerned with the systematic collection of countable and measureable results than with mathematical formula and quantitative standards.

As late as 1950, when many statisticians abroad had advanced the statistical field toward technicality and determinism, Paul Flaskämper defended a particular view of what had by then become a "German" tradition in social statistics. Flaskämper asserted the innovative role of higher mathematical calculation. Socio-economic variables (family, economic production, or education), he claimed, needed to be contextualised in their organic relationship to the respective whole and hence first required logical deduction and intuitive (*anschaulich*) explanation before they could be counted. A factual logic, he argued, was to operate in "parallel" to a numerical logic: the better the entities were defined conceptually, the better they could be measured and hence, the better the statistical result.

This focus on wholeness might call to mind Paul Foreman's article on the downturn of causality Weimar physics due to a turn towards anti-mechanistic interpretations. Flaskämper's statistical methodology was developed in what Foreman called a 'hostile intellectual climate.' However, the research facilitated by my BSHS grant reveals that the picture is more complicated.

Flaskämper had been trained as a philosopher and botanist with then eminent German botanists Schwendener and von Goebel, and experimental work with plants and plant tissue in Munich's botanical gardens instilled in him knowledge of the variety of plant forms and a reverence for the wholeness of the plant and of organic life more broadly. As a student, he also became an active member of the German Monist League, a freethought organisation based on naturalistic ideologies preaching racial hygiene. He considered that vitalist experiences, comprising human senses and will, were capable, if adhering to the "purposefulness" of nature, of not only establishing *Biologie* as an autonomous science distinct from mechanistic and "cold" physics and chemistry, but also guiding cultural, religious and even ethical human life. His lengthy book *The Science of Life* (1913) did not succeed in assuring his position as one of the then en vogue 'philosophizing nature researchers,' however, he never really relinquished his philosophical biologism, even when his career plans were shattered, partly due to conscription in 1915.

From 1920, Flaskämper shifted toward statistical causality and applied mathematics. What may seem like an unlikely trajectory – from natural philosophy of life to social statistics – was in fact facilitated by his intellectual interests and the socio-cultural and political characteristics of the scholarly fields he traversed. This move might seem an inversion of Foreman's historiography, but perhaps "role-hybridisation" in Joseph Ben-David's term, would be a more apt point of analysis. Flaskämper epitomised the tensions and contradictions of his time, negotiating the boundaries between sciences and politics to rescue some aspects of 'mechanist' thought and dismiss others.

Scientific vitalism's dwindling intellectual appeal after World War One and an explosion of national statistical activities account for Flaskämper's turn to social statistics. But only because statistical notions, images and metaphors were compatible with organicist and historicist concepts prevailing in biology, sociology and national economy alike was Flaskämper able to fit his intellectual outlook to his new role. Giving absolute value to organicist "manifoldness" even enhanced his position in statistics because social life, conceived as unmeasurable, remained outside statistical theory as something to which statistical measurement was seen as secondary. Reference to Neo-Kantian philosophy of science helped justifying this move because the quest for a universal methodology of science asserted the integrity of statistics as a science (as *Kulturwissenschaft*), embracing contemporary glorification of life and philosophical description without sacrificing quantification.

Paul Flaskämper with Swastika badge, September 1937
Institut für Stadtgeschichte Frankfurt/Main, PA 16.329

Flaskämper's quick rise to professor of statistics in 1941, however, can only be explained with reference to his self-mobilisation early on as member of both the Nazi Party and the NS University Teachers' League. Had he, in 1947, not been classified a mere "follower" of Nazism – largely because his statistical writings were untainted by *völkisch* and racial ideology while his endorsement of racial hygiene and eugenics as director of the Frankfurt statistical office was unnoticed – his statistical career would likely have come to an end. So, he enjoyed a continual substantial reputation among German statisticians crowned with his appointment as honorary member of the German Statistical Society in 1956.

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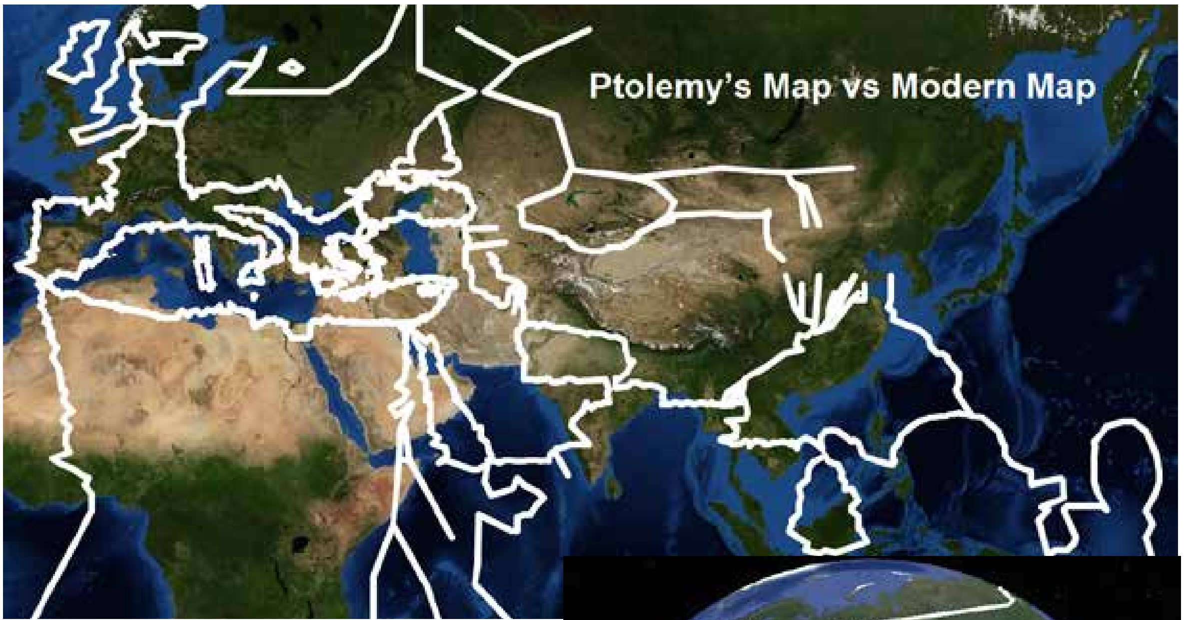
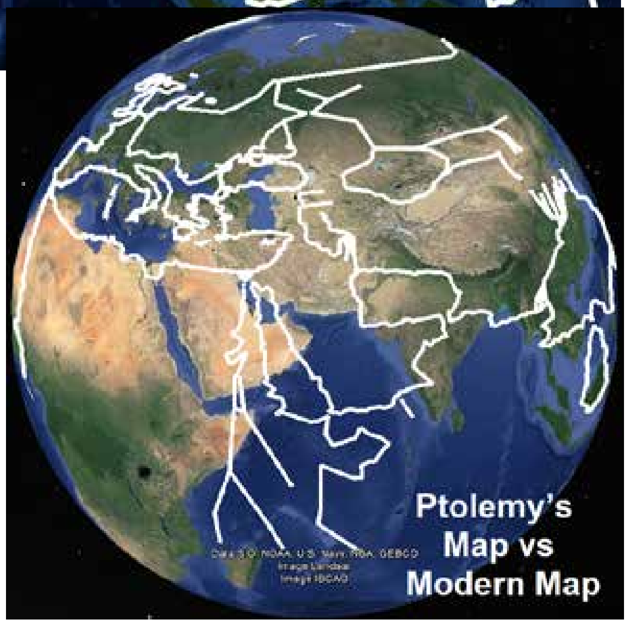
Mistakes & Map-Making in Antiquity

Dmitry A. Shcheglov discusses historical interpretations of the cartography of antiquity

Was there a high accuracy cartography in antiquity? "Yes, there was!" is the bold statement made independently by a number of researchers in recent years. Dennis Rawlins (Baltimor), Lucio Russo (Rome), Irina Tupikova and Klaus Geus (Berlin) share basically the same hypothesis that challenges conventional views on ancient cartography. But how serious is this challenge? Should we get ready to rewrite our textbooks?





Ptomley's map plotted onto a modern map. Images courtesy of Dmitry A. Shcheglov

Paradoxically, the argument for the high accuracy cartography was provided by the most glaring error made by the greatest ancient geographer, Claudius Ptolemy. He accepted a badly underestimated value for the circumference of the Earth: 180,000 stades (equal to 33,300km if he used a stade of 185m as was accepted in the Roman time). This was about 17% less than the true value of 40,000km. Because of this error, the explored part of the world occupied more space on the globe in the east-west direction than it should, whereas the unexplored part—which embraced America and the Atlantic and Pacific Oceans—turned out to be equally underestimated. It is not an exaggeration to say that it is due to this error that we ultimately owe the discovery of America by Christopher Columbus.

Meanwhile, there was another value for the circumference of the Earth, 252,000 stades, put forward by Eratosthenes in the 3rd century B.C. This was accepted by ancient intellectuals. Even Ptolemy used this value in his life-work, the *Almagest*, so Ptolemy's *Geography* with its 180,000 stades is a strange anomaly. Hence it's reasonable to assume that early versions of Ptolemy's map were also initially based on Eratosthenes' value.

A striking phenomenon is revealed by this connection: if we place Ptolemy's map onto a sphere with Eratosthenes' circumference, with distances remaining unchanged, then all its coordinates expressed in degrees improve drastically, down to a complete coincidence with modern maps. Thus researchers concluded that an earlier version of Ptolemy's map, based on Eratosthenes' value, was uncannily accurate, and could even compete with the maps of the Age of Discovery.

However, it's important to emphasise that in itself a coincidence between this reconstructed Ptolemy's map and modern maps cannot prove that they are equally accurate. Before judging the accuracy of this Ptolemy's map, we should answer another question: how accurate was Eratosthenes' measurement of the Earth? Here things get interesting.

In the 19th century it was supposed that Eratosthenes and many other Greek authors used a "short" stade of 157.5m instead of the "Roman" one of 185m. In these stades, Eratosthenes' value for the Earth's circumference works out at 39,690m, and has an error of less than 1%! This result is so spectacular, and the temptation to hail it a triumph of Greek scientific genius is so strong, that it has been eagerly accepted by many scholars. Many distances in the Greek sources, when expressed in the "short" stades, also turn out to be surprisingly accurate. Thus a fascinating prospect emerges: in antiquity there was a tradition of "thrice" high-accuracy geodesy and cartography. Firstly, unknown surveyors measured distances with amazing accuracy, secondly, Eratosthenes calculated the Earth's circumference to within 1% of the true value, and thirdly, on this basis his unnamed successors composed an incredibly accurate map of the world. Then came Ptolemy, who not only pocketed the work of all his predecessors, but also perverted it completely.

But the fascination of this hypothesis is elusive. Its Achilles' heel is the postulated "short" stade. Without it, the whole construction topples like a house of cards. The main argument for the "short" stade is based on comparison between ancient and modern distance measurements: modern distances are divided by their ancient counterparts in stades, giving the length of one stade. The idea is excellent in principle. However, as a rule, ancient sources give only rough distance estimates including various curves of routes that are completely unknown to us. This is why ancient distances are usually overestimated in comparison with modern ones, even when we try to reconstruct ancient routes. Despite this, within the hypothesis of high-accuracy ancient cartography there is no place at all for the notion of "measurement error". The "short" stade is deduced from a tacit assumption of ancient measurements' accuracy. Then this is substituted into Eratosthenes' calculations, which makes his value for the Earth's circumference amazingly accurate. However, a more thorough analysis shows that ancient distances were overestimated by 20% on average. This means that an average stade must have been about 20% longer than the "short" one and closer to the Roman standard of 185m.

The return of the "measurement error" into play gives a more plausible explanation for the high accuracy of the reconstructed Ptolemy's early map. If all distances in antiquity were overestimated, it's no wonder that the same was true of the distance used in Eratosthenes' measurement of the Earth. Consequently, Eratosthenes' value for the Earth's circumference proved equally overestimated. This result has an interesting effect: if overestimated distances are expressed in degrees of an equally overestimated Eratosthenes' globe, then these two errors mutually annihilate each other, and a map constructed on this basis becomes quite accurate. This explains why Ptolemy's map, placed on Eratosthenes' Earth, demonstrates remarkably accurate coincidence with a modern map.

Once the "delusion of high accuracy" is eliminated, everything starts to fall into place. Ancient surveyors measured distances with considerable errors, which was inevitable for that time. Eratosthenes' measurement of the Earth also had an error of about 17%, which should be recognized as an achievement of ancient science rather than as a failure. The incredible accuracy of the reconstructed early map of Ptolemy proves to be a quaint illusion produced by a superposition of two opposite errors. Ptolemy's error in the value of the Earth's circumference indeed contributed to the stretching of his map in the east-west direction. But it can only account for about a half of this stretching, whereas another half was due, most probably, to a banal overestimation of distances underlying the map. There is no need, therefore, to see Ptolemy as an evil genius who did away with ancient cartography and plunged the world into the darkness of ignorance.

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Evolution travels to the colonies

Cristiano Turbil discusses a science dialogue that travelled the world

If the law of Nature is "struggle," it is better to look the matter in the face and adapt yourself to the conditions of your existence. Nature will not bow to you, neither will you mend matters by patting her on the back and telling her that she is not so black as she is painted. My dear fellow, my dear sentimental friend, do you eat roast beef or roast mutton?

Samuel Butler, 'Darwin on the Origin of Species - A Dialogue', *The Press*, 20 December, 1862.

In the 19th century, natural science was crossing the geographical limits of Europe becoming an international discipline promoting research expeditions all around the globe. Reports of research journeys and narratives of evolution and the exploration of unknown territories were becoming fashionable. This, of course, was not limited to England; the dissemination of evolutionary ideas also played an important role in the colonies. Expressions such as "natural selection" and "survival of the fittest" became common in small colonial newspapers too.

In New Zealand, on 20th December 1862, Samuel Butler anonymously published a dialogue on Darwin's *On the Origin of Species* in *The Press*. Although written in a peculiar style, Butler's dialogue offered an accessible explanation of Darwin's hypothesis of evolution to New Zealand citizens. The narrative adopted by the British born emigrant, Butler, was a mix of satirical writing and scientific explanation combined into a deep philosophical analysis. From the 1870s onwards, Butler started a crusade against Darwin and his hypothesis of evolution. However, in the early 1860s, Butler declared without hesitation: 'I was one of Mr. Darwin's many enthusiastic admirers, and wrote a philosophic dialogue (the most offensive form, except poetry and books of travel into supposed unknown countries, that even literature can assume) upon the Origin of Species' (Butler's Notebook).

The dialogue mimics a colloquial conversation between two individuals: 'C' a very conservative Christian and 'F' an enthusiastic middle class admirer of Darwin's work. Starting with a direct question from 'F': 'So you have finished Darwin? Well, how did you like him?' it tried to explain how Darwin's work was something more than a piece of writing 'so hard and logical' as defined by 'C'. Butler's aim was to 'catechise' the colonials, explaining the potential of evolution with a simple language and a very jocular colonial terminology. Butler explained evolution via breeding of cats, parrots and sheep but also satirically attempted to conciliate Darwinism and Christianity.

The dialogue attracted a great deal of discussion in the colony and even the Bishop of Wellington responded to Butler with a long letter also published in *The Press*. The letter, entitled 'Barrel-organs' stated that Darwin's work was reiterating ideas already known, not promoting any revolutionary new understanding of the origin of life. Butler replied to the Bishop and recalled the episode in his own notebooks: 'I remember answering an attack (in the Press, New Zealand) on me by Bishop Abraham, of Wellington, as though I were someone else, and, to keep up the deception, attacking myself also. But it was all very young and silly.'

Aside from this quarrel, Butler's dialogue has another story to tell. The dialogue was not only acclaimed by New Zealand citizens; Butler's popularisation of Darwin's science was even able to cross the borders of the small colonial community and make a rapid journey back to England. As reported by Henry Festing Jones, friend and biographer of Butler, a copy of the paper was sent to Darwin. Darwin forwarded it to an English editor with a letter, dated 24th Mar 1863, speaking of the dialogue as 'remarkable from its spirit and from giving so clear and accurate an account of Mr. D's theory' and highlighting that fact that the dialogue was 'also, remarkable from being published in a Colony exactly 12 years old, in which, it might have thought, only material interests would have been regarded'.

Darwin was fascinated by this dialogue. At first, he thought it was written by the German geologist Julius von Haast who was conducting research on rock formation in the Canterbury region. On 18th July 1863 Darwin wrote to Haast: 'I wonder whether you were the Author of a very amusing & really excellently done Dialogue on Natural Selection, in a New Zealand paper, which was sent to me?' Haast presumably replied to Darwin revealing the name of Butler but this letter did not survive. The solution to this interesting epistolary exchange arrived only later on in 1863 when Emma Darwin attached to a letter to Hooker (7th Dec 1863): '2 squibs by the Author of the Dialogue in the New Zealand paper on Origin. He is a Mr Butler Grandson of the old master of Shrewsbury C.'s schoolmaster.'

This short story about a dialogue written in a very young colony in New Zealand illustrates how Victorian scientific ideas rapidly travelled all around the globe, and how discussions of science might even begin with questions like 'do you eat roast beef or roast mutton?'

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Forgotten Freight? Representations of Rail History

Erin Beeston on the presentation of the history of freight at the Museum of Science & Industry

The 1830 Warehouse and capstan signage, photographs © The Museum of Science & Industry

Liverpool Road Station, Manchester, opened in 1830 and is famed as the world's first passenger railway station. It is not surprising that this great 'first', a popular trope in history and science communication, has been mostly studied in terms of the engineering of the line by the 'heroic inventor', George Stephenson, and the innovative passenger service. What has been largely forgotten is the 130-year period of purely goods transportation which followed the closure of the passenger service in 1844.

The focus on the movement of people has been mirrored in the interpretation of the Station, now the site of the Museum of Science and Industry, Manchester, over the past 30 years. Yet, if the freight uses of the buildings, tracks and spaces around site were better explained to visitors, stories of new technologies, of people and workers, and a sense of how goods were moved in and out of Manchester could transform their experience.

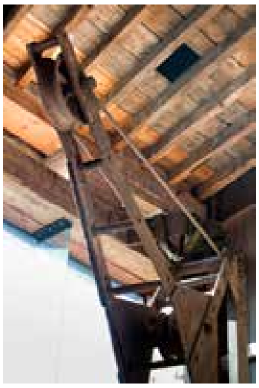
Liverpool Road Station is a unique survival whose structures provide clues to the freight heritage: a gantry for a travelling crane, signs for capstans, and marks of where a steam engine once stood at the end of the 1830 Warehouse. This warehouse, erected in less than five months during 1830, is the oldest surviving railway warehouse. Its restoration in the 1990s was championed by museum staff, who saw it as the most significant building on site. In 1992 an exhibition was planned to explain the site 'and surrounding water, road and rail links as a focus for distribution of materials, goods and services in the area' (Greene & Porter, 'The Museum of Science and Industry in Manchester: the local and historical context' in John Durant, *Museums and the Public Understanding of Science* (NMSI, 1992). In the end, no permanent exhibition was completed, though a gallery, 'Warehouse of the World', ran from 2000 to 2011, highlighting the global transit of goods in and out of 'Cottonopolis'. The warehouse continues to provide visitors with the strongest sense of the freight heritage at the museum. A jib crane used for transporting heavy loads into the warehouse at rail level is in situ and visitors can glimpse a view of a shipping clerk's office in Bay 2.

Another significant surviving building is the Shipping Shed, currently home to the 'Power Hall' display. At the close of the 1840s, London and North Western Railway, owners of Liverpool Road from 1846 to 1923, were encouraged to improve the station: a new horizontal high pressure stationary steam engine was purchased in May 1855, probably to power the lifting equipment in the new building. The current museum display comprises of different types of engines, although nothing remains of the original steam engine. Through the 1853 New Streets Act, Manchester Corporation enabled the construction of the Shipping Shed by providing for the widening of Wellington Place (now Lower Byrom Street) and the demolition of 69 properties. Displacement of people for the construction of railways was common in mid-19th century urban centres, so presenting the history of lost streets might help visitors understand how the station shaped Manchester.

Two original buildings from 1831, Cotton Warehouse 1 and 2, were destroyed by fire on 23 May 1866. The 1830 Warehouse only survived the fire owing, according to the Manchester Courier, to the Salford Fire Brigade who, with a water hose, 'made a gallant stand at the tramway bridge' and dampened the vulnerable timber frame of the older warehouse. The aftermath of the fire allowed London North Western to implement existing plans to re-arrange Liverpool Road and create a new viaduct. This viaduct served a new Bonded warehouse, operational by 1869, which now lies beyond the boundary of the museum, further complicating the creation of a unified site narrative. One possible solution to this could be an elevated viewing point of this warehouse, potentially from within the adjacent Byrom Street Warehouse. This building was the last to be constructed on site in 1879, after four more streets were demolished. By renaming this building the Great Western Warehouse, the museum has highlighted its historic shared use: Great Western predominantly ran railways in the South-West; Manchester was their most northern hub for haulage.

It's unclear when precisely a system for hydraulic power was installed on site, though it's likely to have been adopted during construction works in the 1870s: it certainly predated Manchester Corporation's 1894 power supply. Steam powered hydraulic engines on site fed high pressure water pipes that could be used to power equipment such as cranes. Evidence from the London and North-Western's New Works Accounts lists new hydraulic machinery for Liverpool Road in November 1882 and 1883. By 1889 there were 19 hydraulic powered capstans, used to haul trucks around. The location of capstans is marked by surviving signs mounted to the exterior walls of the warehouses. An example of a hydraulic pumping engine from the Water Street Pump House is displayed in the Power Hall, but the use of this power source at Liverpool Road is absent from the narrative.

Whilst the 1830 Warehouse has been researched and interpreted to some extent, the outside spaces and other warehouses at the museum are known only to those who explore exterior signage. One of the purposes of my PhD on Liverpool Road Station is to suggest how the legacy of freight, and of working life on and around the site could be incorporated into a stronger site narrative in the future. For example, the Power Hall could



A jib crane from Bay 2, 1830 Warehouse. © The Museum of Science & Industry

be interpreted to inform visitors of how goods were hauled around the site using machinery powered by hydraulics and the story of buildings, and streets no longer visible to visitors could be recreated in the spaces they were most strongly associated with. The museum is currently working towards a Masterplan for the site, which focuses on the railway heritage and helping visitors understand the outside realm. As staff work towards unifying the large site into a coherent story for visitors, the opportunity to give freight more prominence could transform how Liverpool Road Station is understood.

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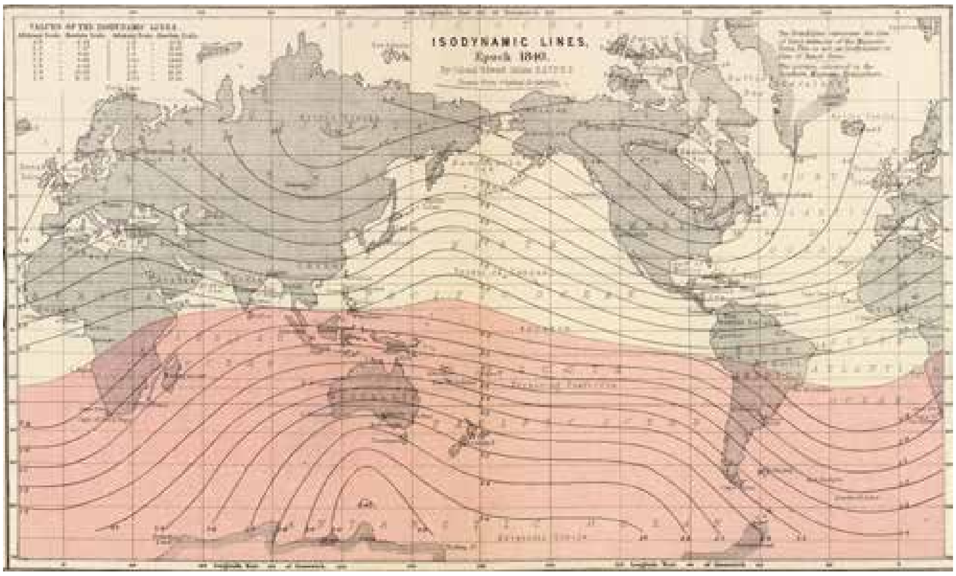
IEEE History Centre REACH

The IEEE History Center is partnering with the IEEE Foundation to launch a new program, REACH: Raising Engineering Awareness & Appreciation through the Conduit of History. Pre-university STEM (Science, Technology, Engineering & Mathematics) education is important, and because technology has had such a huge impact throughout human history and particularly in forming the modern world, history is an ideal conduit to convey these important concepts, and all students, whether interested in STEM or not, take global history in middle and or high-school.

REACH will take the IEEE History Center's deep resources in engineering history - including articles, oral histories, milestones, and archives - to produce short videos and related curricular materials around case studies that illustrate the importance of engineering in history, and have these adapted into high-school global history courses. The IEEE Foundation has committed to help us raise funds from individuals, corporations and foundations beyond our normal operating to carry out this initiative. We are currently gathering an initial panel of educators to help us better define the most appropriate topics and the necessary material. Institutions or educators who might be interested in being part of this initiative should contact History Center Senior Director Mike Geselowitz at m.geselowitz@ieee.org or +1 732 562 6022.

Victorian Science at Home & Away

Richard Bellon explores how 19th century intellectuals roamed the world and the universe (sometimes without leaving London).



An illustration from Terrestrial Magnetism *(1856) by Edward Sabine. Image courtesy of the David Rumsay Map Collection, www.davidrumsey.com*

The distinguished German botanist Matthias Schleiden started his popular lecture on the geography of plants in the 1840s with a rhetorical question. 'Could we choose a better starting-point [than London],' he asked, 'if we would, for any purpose whatever, make a survey of the earth?'

Why? There was a curious geographical fact: trace a hemisphere on the globe to encompass the largest possible amount of land surface and London rested almost exactly at its centre. Much more importantly, he explained, nowhere else had richer collections of natural and geographical knowledge. Explorers of all corners of the world gravitated to London and deposited the fruit of their toil—observations, maps, collections of specimens. Scientists then stitched together these fragments to seek a 'full knowledge of the Whole.'

Schleiden's celebration of London as a centre of exploration captures a defining characteristic of 19th-century science: here and in a few other privileged metropoles—global catchment basins where knowledge, material and people congregated—men pursued the goal of 'comprehending the whole earth in one intelligent glance.'

This ideal had a long and impressive pedigree. In the early 19th century the illustrious French naturalist Georges Cuvier explained that nothing could rival a good museum for the study of the natural world. He acknowledged that the "sedentary naturalist" might not be able to see nature in all its vivid drama, but he could do something even more powerful: he could accumulate relevant facts from every corner of the globe. In the field, a naturalist could only see the scene directly before him. His views were blinkered, broken and fleeting. In a well-stocked the museum, however, he could array the whole of nature instantaneously before his eyes and mind.

In Britain during the first half of the century, Cuvier exemplified the practice of natural history. The Scottish natural philosopher David Brewster placed him on a pedestal next to the great Isaac Newton. Cuvier earned these laurels, Brewster said, in large part by painstakingly arranging 'the objects of his research in splendid halls, and displays at one view the wonders of the remotest ages, and the most distant kingdoms.' Brewster often feuded with William Whewell, the Cambridge philosopher of science, but on this point they agreed. For Whewell, the scientist must above all else pursue 'the true bond of unity by which the phenomena [of nature] are held together.' For observational sciences, like his own groundbreaking work on tidal theory, comprehensive repositories of data were essential because they allowed the 'scrutinizing eye and judicial mind' to grasp 'a simultaneous view of the condition of the whole globe.'

This idealization of virtual travel placed analysing data in a fixed location above collecting it in the first place. Brewster, reflecting in 1846 on the progress of geology, noted that 'every geologist who has displayed genius' had dedicated much of his life to wading in rivers and clambering over rocks, hammer at the ready. While these brilliant labours would always remain necessary, geology now wanted a 'priesthood, who shall worship her in the closet, where the philosopher's inductive glance may dispel the illusion of the observer's eye, where a comprehensive grasp of science may correct the narrowness of his views.' Collecting specimens and observations, Whewell maintained, 'may be compared to the gathering of cotton from the tree. The separate filaments must be drawn into a connected thread, and the thread woven into an ample web, before it can form the drapery of science.'

Gathering "cotton" from around the world was neither cheap nor straightforward. Increasingly, only national governments had the organisational and financial resources to underwrite the ambitious search for the 'true bonds of unity' in nature. Geology, botany and zoology came to depend on government beneficence to fund ever-growing—and thus ever-more expensive—collections of physical specimens. When Cuvier died in 1832, the public research herbarium at the Museum of Natural History was supplemented in Paris by several comprehensive private repositories of plant specimens. These substantial personal herbaria vanished over the next four decades. Their owners died and no one else was either willing or able to spend the tremendous amount of money needed to sustain them. At the heart of the public herbarium at the Royal Botanic Gardens at Kew in London were tens of thousands of specimens originally owned by William Hooker, Kew's first director, and his friend, George Bentham.

The physical sciences likewise turned to state support. An ambitious project to map the geographical distribution of terrestrial magnetism, conceived in the 1830s, absorbed more than £100,000 from the British treasury. For this money, Whewell rhapsodized, her majesty's government advanced 'by far the greatest scientific undertaking which the world has ever seen.' He believed that the amount of time necessary to understand the 'magnetic constitution of the earth' had fallen from centuries to mere years. The scientists who directed the worldwide collection of magnetic readings also pioneered graphical representations of the resulting data—the physical-science equivalent of carefully arranged natural-history specimens. The astronomer John Herschel noted approvingly that magnetic maps with graceful isophenomenal lines spoke 'immediately to the mind.'

These crusades to comprehend natural phenomena in single comprehensive glances wove science deeply into the fabric of European imperialism. On the most obvious level, the global collection of specimens and data depended absolutely on the outward radiation of European political, military and economic power. The dependence on government further inspired scientists to offer enthusiastic service to colonial projects. As the mathematician George Peacock promised in his 1844 presidential address to the British Association for the Advancement of Science, scientific labours 'will equally tend to promote the interests of knowledge and the honour of the empire.'

The career of William Hooker's son Joseph illustrates this intersection of scientific labour, natural knowledge and imperial honour. The younger Hooker became one of the century's greatest "sedentary naturalists" but, like his close friend Charles Darwin, only after apprenticing as a field naturalist. Hooker first served as naturalist on a naval expedition to survey the magnetism in the southern hemisphere and then spent several years in India where he aspired to make 'the most important [botanical collections] ever formed.'

His ambitions relied on the personal patronage of Britain's Governor-General of India, the Marquis of Dalhousie. Without his lordship's support, Hooker would not have been able to gain admission to the reclusive Himalayan kingdom of Sikkim, 'ground untrodden by traveller or naturalist' despite its importance to understanding the botanical geography of India. In 1849 a chronically tense relationship with his unwilling hosts finally broke when he and a companion, a local British official, slipped illegally across the border into Tibet. The two men were arrested and held for several weeks. Dalhousie dispatched an invasion force which avenged this insult by annexing a valuable chunk of Sikkimese territory.

As much as Hooker valued his field experiences, he was convinced that they 'are pretty well thrown into the sea' if the government did not give him the time and money to name, systematize and distribute his collections and observations back in London—his haul of "cotton," accumulated at the cost of so much time, money and danger, was worthless until he spun it into thread and wove it into the tapestry of science. Thanks to intense lobbying by his scientific friends, he received the financial support needed to embed his Indian materials in investigations that the ranged 'over the whole surface of the globe.' Within a few years he exploited his expertise in the global study of plant classification and distribution to support Darwin's theory of evolution by natural selection. When he succeeded his father as Kew's director in 1865 he doggedly maintained its role as 'the botanical centre of the world, [which] literally carries on all the Economic and Scientific work of the Empire under the direction of various departments of state.'

The 19th century was a grand age of scientific travel, but, at least in the opinion of elite scientists, the greatest discoveries—and perhaps even the most heroic adventures—unfolded in the "splendid halls" of great metropoles like London and Paris where men of intellectual courage and disciplined intelligence traversed the world with their eyes and minds. Cuvier captured succinctly the utopian principle driving this practice: 'the traveller can only travel one road; it is only really in one's study that one can roam freely throughout the universe.'

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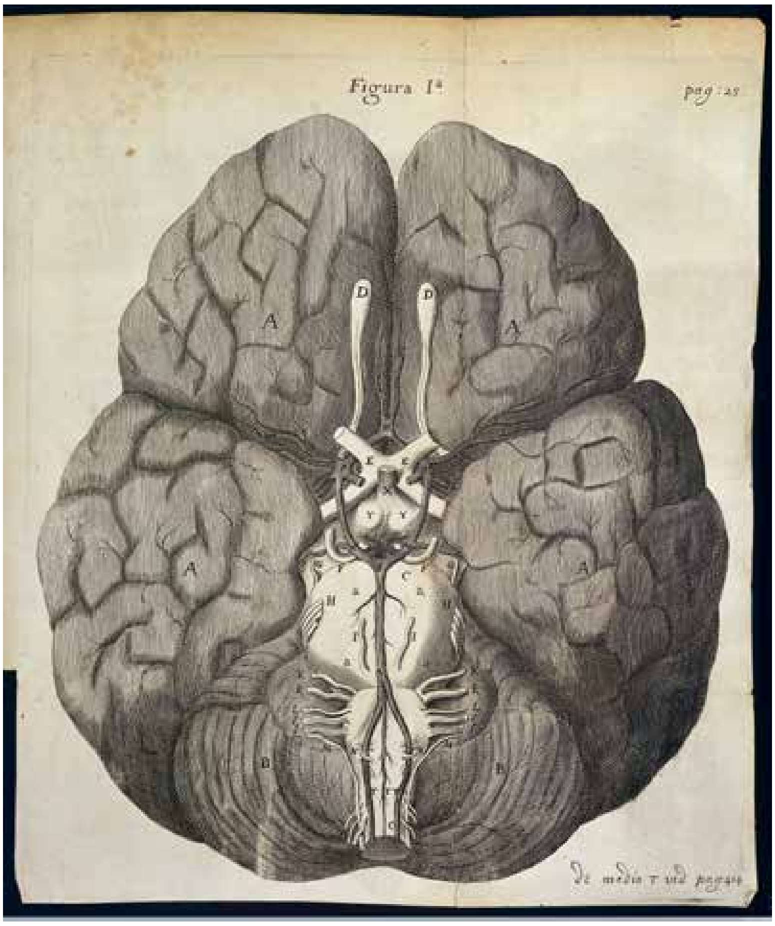
The Temperate House in Kew Royal Botanic Gardens, circa 1860. Image courtesy of James Morley.

Moving Minds: Cavendish & the Matter of the Mind

Anne M. Thell explores conceptions of the human mind from the 17th & 18th centuries



T. Willis, Cerebri anatome : cui accessit nervorum descriptio et usus. Amsterdam *: G. Schagen, 1664. Opp. p.32, fig. 1a: Human brain, with cerebellum & nerves. Courtesy of the Wellcome Library, London.*

Historicizing the study of the brain has become a major line of inquiry for both historians of science and philosophy and literary scholars. When we think about 18th-century understandings of the mind, we often turn first to British empiricist John Locke, whose model of consciousness posits the senses as the source of all ideas; we view this sensory evidence, according to Locke, from within the internal, individuated space of the mind. Locke is primarily interested in epistemology — as he famously notes in *An Essay Concerning Human Understanding*, he does not wish to 'meddle with the Physical Consideration of the Mind' — but his theory still forms the major current along or against which later 18th-century concepts of mind flow.

If we look at the history of neuroscience in the early modern period, we'd also likely turn to Thomas Willis, whose extensive research on neuroanatomy several decades before Locke's *Essay* led to his magnum opus, *Cerebri Anatome* (1664) (illustrations for this text were created by Willis' friend Christopher Wren). Willis' book had little immediate impact on medical practice, though it informed understandings of the brain and nervous system over the next two centuries. We should note, however, that Willis was driven by how the study of the brain might allow access to the divine soul, enabling us to 'look into the living and breathing Chapel of the Deity' (Willis, 'Epistle Dedicatory', Part V, *The remaining medical works of that famous and renowned physician Dr. Thomas Willis*, trans. Samuel Pordage, London: 1681). In this sense his study is rooted in 17th-century religious doctrine and is problematized by later, material understandings of the mind.

Few historians have studied Margaret Cavendish's contribution to early modern debates about the nature and function of the brain; interestingly, while she has long been considered a social and philosophical outlier, her resolutely material account of nature — and the mind — can be seen as prescient of later understandings of perception and cognition. In fact, as David Cunning has suggested, Cavendish's materialist theory of mind 'anticipates arguments and views that are found in some of the more famous philosophers that follow her—for example, Locke, Leibniz, and Hume.' Moreover, Cavendish's 'view is an important chapter in the history of materialism, and it may even be correct.' Similarly, Gabrielle Starr has argued that Cavendish raises ideas that are theorized only much later in the fields of aesthetics and, eventually, neuroscience.

Cavendish was a vocal critic of the mechanical and experimental philosophy espoused by the early Royal Society of London, and while some of her thinking seems wildly eccentric to us today (and did not have much influence at the time), there are several important aspects of her later philosophical work — such as her thoroughgoing materialism and her organic theory of matter — that are not only important contributions to the philosophical debates of the era, but also relevant to modern notions of cognitive function.

Although she had no formal education, Cavendish wrangled with ancient and contemporary philosophy for nearly two decades, and her later philosophical texts — notably *Philosophical Letters* (1664), *Observations upon Experimental Philosophy* (1666), and *Grounds of Natural Philosophy* (1668) — offer a salient theory of nature that is complex but largely consistent. Here she outlines her system of organic materialism, which envisions all parts of nature as material, self-moving, rational, sensitive, and alive; in other words, she imbues all matter with life, perception, and volition. She is thoroughly rationalist in that she posits reason as the basis of all knowledge. Like Hobbes, she is entirely materialist in that she denies the existence of incorporeal souls or spirits in nature (and in fact she was one of the only philosophers of the age who dared to agree with Hobbes on this point). Unlike Hobbes, however, Cavendish rejects mechanism and instead explains all natural change via the intentional configuration and reconfiguration of the organic parts of matter. In this pan-psychic system, each part recognizes its surroundings and consciously moves itself (and hence volition trumps brute force). Finally, because all of nature consists of not only material but self-knowing and perceptive matter, Cavendish's natural philosophy collapses ontology and epistemology. To be is to have a body that knows and moves.

Even though all parts of nature are rational (and thus all parts can 'think'), Cavendish goes to great lengths to show how the type of cognition that occurs in the human brain is uniquely powerful and productive. For example, Cavendish argues that because the mind does more than respond to its immediate environment, its productivity cannot be understood via sensory experience or the mechanist collision of parts. Instead, thinking occurs when the material parts of the mind move, either in response to external stimuli (like sensory input) or of their own accord (via memory, dreams, imagination, etc.). For Cavendish, thoughts are powerful things: 'they do not follow each other like Geese,' nor are they 'like Water upon a plain Table, which is drawn and guided by the finger this or that way' (*Philosophical Letters*, p. 31). Instead, thinking is an autonomous, embodied process, and the mind's productions—thoughts, memories, dreams—are similarly material. This means that even fancies, however 'improbable, or impossible,' 'are not No-things, but as perfectly imbodied as any other Creatures' (*Philosophical Letters*, p. 448). As Cavendish sees it, the imagination has the capacity to produce new thought at will (with or without external stimuli), and is therefore a potent generative force.

Intriguingly, Cavendish's philosophy envisions all matter in a state of constant, self-directed flux; motion is a precondition for being and knowing, and thought occurs when the material parts of the mind move (and the more quickly a mind moves, the more it thinks). This emphasis on moving matter might help to explain why Cavendish chose to attach a fantastical travelogue, *Blazing World*, to *Observations upon Experimental Philosophy* in both 1666 and 1668. In fact, Cavendish might have chosen a travelogue as the companion piece to *Observations* because it has important theoretical links to her natural philosophy; in this sense, *Blazing World* dramatizes the content of *Observations* by depicting a universe—and a mind—in constant, dazzling motion.

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Conference Announcement: Physics and the Great War

Saturday, June 13, 2015
10.30am - 5.30pm
St Cross College, University of Oxford

Arguably the First World War saw the greatest advent of new science and technology and the role of science in warfare than any conflict hitherto. On land the innovations of barbed wire, machine guns and eventually, tanks changed the nature of land battles. At sea, radio communications changed operation of surface fleets and the introduction of submarine warfare changed the nature of war at sea. This war saw also the advent of aerial warfare which was to change the nature of all future wars. This conference seeks to review the key ways in which physics and its mathematics changed the nature of conflict from various points of views: technical, historical and sociological.

Registration to attend this conference is free, but must be confirmed. To register or read more, see the website:

www.stx.ox.ac.uk/happ/events/physics-and-great-war-one-day-conference

Conference Report

The Experimental Philosophy, the Mechanical Philosophy, & the Scientific Revolution

Institute of Advanced Study, Durham University, June 5th 2014

The period referred to as the "Scientific Revolution" is often characterised in terms of the replacement of an Aristotelian world-view by "the mechanical philosophy" of René Descartes, Pierre Gassendi and others. Another theme often associated with the Scientific Revolution is a special emphasis on empirical observation and experiment as providing the basis for science, a theme often captured by the phrase "the experimental philosophy."

"The mechanical philosophy" and "the experimental philosophy" have sometimes been taken to be synonymous. If the mechanical philosophy is interpreted as an encouragement to search for explanations that appeal to mechanisms, as in the workings of a clock, then a close link with experiment seems plausible. Alternatively, if the mechanical philosophy is understood as a change in the ultimate ontology of the world, with the replacement of Aristotelian forms by nothing other than moving corpuscles of matter possessing shape and size, then a link with experiment appears less plausible. The aim of this workshop was to explore the range of theses involved in the mechanical and experimental philosophies, to assess their respective roles in the development of the natural sciences during the 17th century, and to consider the relationship between them.

The workshop was organised to coincide with the philosopher and historian of science Alan Chalmers' (University of Sydney) visit to Durham University. Its theme was based around Chalmers' work in which he argues that the experimental sciences prospered in the 17th century in a way that owed little to mechanical philosophies, a position which is at odds with the received doctrine that it was the replacement of the Aristotelian worldview by the mechanical philosophy that opened the way for experimental natural philosophy. For instance, Chalmers has used the case of Blaise Pascal's and Robert Boyle's hydrostatics to argue that the Scientific Revolution is better characterised by the experimental investigation of "intermediate causes" such as weight and pressure than by the positing of "ultimate causes" associated with the corpuscular matter theories of the mechanical philosophers.

In the workshop's opening talk, Chalmers furthered this line of argument in a paper entitled 'Qualitative Novelty in 17th-Century Science: Hydrostatics from Stevin to Pascal' in which he presented a detailed exposition of the introduction of the concept of pressure as an isotropic force to replace the inadequate concept of weight in hydrostatics during the first half of the 17th century (Chalmers' paper is published this month in *Studies in History and Philosophy of Science*, Vol. 51, pp. 1-10).

Sophie Weeks (University of York) then discussed 'Experiment and Matter Theory in the Work of Francis Bacon,' focusing on the notion of the uniformity of nature and its influence on the development of experimental natural philosophy during the succeeding decades of the century. We then moved to the later part of the 17th century and the beginning of the 18th with Rob Iliffe's (University of Sussex) talk on 'Newton, Experiment and the Mechanical Philosophy' which explored the relationship between the experimental and mechanical philosophies in the work of Isaac Newton.

The penultimate talk was David Wootton's (University of York) provocatively-titled 'In Defence of the Mechanical Philosophy.' Wootton defended the mechanical philosophy against Chalmers, arguing that the mechanical philosophy played an important role in the development of the experimental sciences in that it dispensed with the long-entrenched Aristotelian worldview, thereby allowing experimental natural philosophy to flourish during subsequent decades. Unsurprisingly, this engendered a fascinating and lively discussion between Wootton and Chalmers.

The workshop's closing talk was David Knight's (Durham University) 'Clockwork, Chemistry and the Scientific Revolution.' Knight explored the mechanical metaphor of the "clockwork" universe, illustrating his talk with a wealth of images of Orreries and other mechanical contrivances used to understand the natural world by appeal to physical mechanisms.

The workshop was well attended by a mix of historians, philosophers and theologians all of whom contributed valuably to the discussion. The organisers would like to express their sincere thanks to all who contributed to and attended the workshop and to the British Society for the History of Science and the British Society for the Philosophy of Science for generously funding the event.

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The *Viewpoint* Interview

Ben Marsden is a Senior Lecturer in the Department of History at the University of Aberdeen, Director of the Centre for History and Philosophy of Science, Technology and Medicine (CASS) and the Chair of the BSHS Conferences Committee

Who or what first turned you towards the history of science?

At secondary school I was interested in odd combinations of subjects - especially mathematics, music and literature. *Gödel, Escher, Bach* made a big impression. Requests that I "conform" and abandon my "ridiculous" interdisciplinary aspirations had no effect. My father had trained as a chemical engineer before becoming a sociologist so, presumably sensing my nascent historical skills, he urged me to study mathematics. As an undergraduate and then a victim of Part III at Cambridge, I attended Piers Bursill-Hall's optional history of maths lectures. Piers helped me write an essay, on George Green, which I needed to apply for the MPhil in HPS. Amazingly the Cambridge Philosophical Society lent me volumes of their *Proceedings* so I could read Green's papers at home: there was something thrilling about handling them (digitizers please note). I also remember rifling through Newton's annotated copy of his *Principia*, to the obvious alarm of the rare books librarians. I dropped one plan to research the history of non-Euclidean geometries (in Cambridge) and another to go into artificial intelligence research (at Essex). Fate (or was it money?) led me, instead to Kent where I started working on a PhD with Crosbie Smith. Luckily Graeme Gooday and Jon Agar were there too.

What's your best dinner-table history of science story?

My worst history of science story-telling experience was at the 'Technological Change' conference in Oxford (1993). I dimly recall late-night folk music (was Jeff Hughes there?), a pub 'lock-in', obligatory alcohol-fuelled story-telling – and a creeping sense that the extended failure of the Dover-Calais telegraph cable in 1851 was neither so poignant nor so hilarious as I imagined.

What has been your best career moment?

Probably the year I spent as Senior Fellow at the Dibner Institute for the History of Science and Technology on the MIT campus in Cambridge, MA – if an entire year counts as a moment. Happy memories, great friends, wonderful resources.

And worst?

Thus far: watching the slow packing up of the Dibner Institute and its library in 2006 – although some of its activities continue at the Huntingdon Library.

Which historical person would you most like to meet?

There are a few questions I'd like to ask academic engineer W. J. Macquorn Rankine – before we file for compassionate divorce. I guiltily suspect an evening with James Clerk Maxwell in his rooms on Aberdeen's Union Street would be more entertaining, though – and perhaps there'd be follow-up postcards. From a methodological point of view, I think I'd prefer to be a non-participant observer, but close up. A little further back in time, I could, if permitted sit very happily in the audience for an early performance of Bach's Matthew Passion.

If you did not work in the history of science, what other career might you choose?

Pure mathematicians were supposed to become actuaries or work at GCHQ cracking codes and spying. Those were non-starters. I'd be a pianist, accompanist and répétiteur. At this point I should state that my piano teacher at the Guildhall School of Music & Drama (Bridget Wild, Claudio Arrau's assistant and student) did several times suggest to me that plumbers never went hungry.

What are your favourite history of science books?

Most influential early on was Morrell and Thackray's *Gentlemen of science* – a beautifully written blend of rich empirical history and penetrating analysis. Formative, inspiring or clarifying in various ways have been Desmond's *Politics of evolution*, Biagioli's *Galileo, courtier*, Ritvo's *The animal estate*, Livingstone's *Putting science in its place* and Nye's *Technology matters*.

What would you do to strengthen the history of science as a discipline?

Keep talking to all of our existing and emergent audiences, interest groups and partners. But also, in admittedly tricky funding conditions for the humanities, don't budge (too much) on whatever scholarly values happen to be core to you! Those of us associated most closely with humanities groups in universities in the UK (including Scotland) are living in very interesting times. As some politicians hint that humanities degrees may damage careers, "history" is doing quite a bit of re-thinking. "History of science" ought to be strong in "impact" terms, thanks to this "bridging" discipline's obvious relevance to science, technology and medicine. I'd like to think it could be a significant part of a case in favour of sustaining support for the humanities.

How do you see the future shape of the history of science?

In the short term, I'm curious to see: the next phase of the ongoing and to some unexpected rapprochement between philosophy of science and history of science; the seemingly unstoppable mutual engagement of history of science with historicist literary studies; and all the great work being done in connection with museums. Is there room for a newly productive relationship between history of science and the social sciences?

The British Journal for the History of Science

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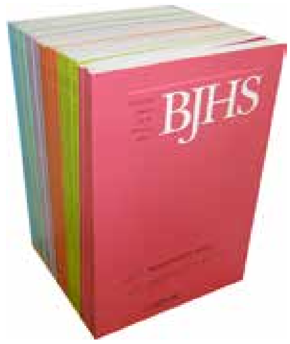
- Diarmid A. Finnegan and Jonathan Jeffrey Wright, 'Catholics, science and civic culture in Victorian Belfast'
- Chris Manias, '*Sinanthropus* in Britain: human origins and international science, 1920-1939'
- Taro Mimura, 'The Arabic original of (ps.) Māshā'allāh's *Liber de orbe*: its date and authorship'



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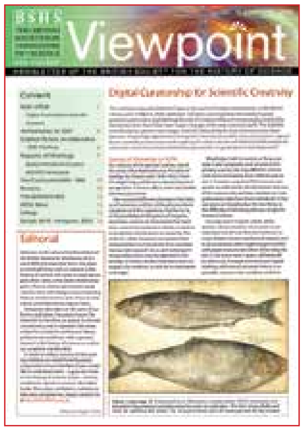

Contributions

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