

INTRODUCTION

This characteristic of modern experiments – that they consist principally of measurements – is so prominent, that the opinion seems to have got abroad that, in a few years, all the great physical constants will have been approximately estimated, and that the only occupation which will then be left to men of science will be to carry on these measurements to another place of decimals ...

James Clerk Maxwell (1871)¹

Each observer went out ticketed with his ‘personal equation’, his senses drilled into a species of martial discipline, his powers absorbed, so far as possible, in the action of a cosmopolitan observing machine.

Agnes Clerke (1902)²

The astronomers who are to-day to make their observations have all gone through the preliminary process of what is technically known as correcting their personal equation ... What a gain to political life in practice it would be if we could only correct the personal equation of those who think, write, speak, and act in the sphere of politics! Suppose, among our members of Parliament, we could exactly measure and allow for the inordinate vanity of one, the litigious querulousness of another, the professional bias of a third, the hereditary, national or sectarian prejudices of a fourth ...

Sydney Morning Herald, 9 December 1874

On 9 December 1874, in Sydney, New South Wales, a rare transit of Venus happened to coincide with a round of important local elections. In the *Sydney Morning Herald* for that day, set among articles about ship arrivals, a smoking volcano in the Torres Strait and commodities quotations from Singapore (nutmeg, mace, pepper, pearl sago, tapioca, rice, coffee, cigars, etc.), there is an article entitled ‘Science and Politics’. The article sets out to contrast these two ‘very different phases of human action’. On that morning, at the observatory on Flagstaff Hill, astronomers were straining to time with the utmost precision the passage of the silhouette of Venus as it crawled across the surface of the sun. Sydney was just one of hundreds of spots on the globe where similar observations were being made on that day. The goal was to measure the distance between the earth and the sun to the highest possible degree of precision permitted by modern methods of measurement. Meanwhile, on the same day, in the world of Sydney politics, the hustings at Hyde Park was a spectacle of ‘passion, excitement, mis-

representation, manoeuvring, and questionable agencies'. In the *Sydney Morning Herald*, the practice of science – with its focus on dispassionate observation – was drawn in remarkable contrast to the practice of politics, 'which depends on the coloured and distorted lens of party spirit'.

There is some irony in how the *Sydney Morning Herald* article uses the case of the transit as an opportunity to meditate on the separation of science and politics. In fact, the worldwide transit enterprise of 1874 was thoroughly shaped by national political ideologies. Five major world powers conducted separate transit of Venus programmes. Expeditions from Britain, France, Germany, Russia and the United States each set out with the same goal of measuring the sun's distance. On this unusually crowded international stage, participants and commentators alike approached the question of the sun's distance through the 'colored and distorted lens' of nationalism, and the whole enterprise would owe much of its size and shape to the air of international competition that gathered around it.

Nationalism with respect to science was commonplace in nineteenth-century Britain. It was also curiously cosmopolitan, mixing national pride in scientific achievements with a view of science as a pursuit that knows no political borders. So, for example, while the press in Britain often described the British programme with patriotic enthusiasm (an attitude shared by many astronomers and politicians), at the same time the press assumed that the astronomers of different countries were collaborating much more closely than in fact they were. Similarly, while readers were regaled with the historical achievements of British science, they were also reminded of the universal benefit certain to be brought by such ambitious scientific pursuits.

In the case of the transit of Venus, each participating country acted according to its own interests, and yet the underlying sense of the universal character of science remained. As the *Sydney Morning Herald* put it, the 'practical applications' of science 'are rendering the greatest service to human wellbeing'. Even the Admiralty saw itself as contributing to 'the common stock of accurate science'.³ Science, according to this standard ideology, was essentially cosmopolitan. At the same time, however, to be a cosmopolitan figure on the international stage one must have a strong individual character. In the case of the transit of Venus, each participating country acted in the interest of its own national scientific honour. That intermingled ideology is expressed in Agnes Clerke's summation of the enterprise: 'Every country which had a reputation to keep or to gain for scientific zeal was forward to co-operate in the great cosmopolitan enterprise of the transit'.⁴

That intermixture of nationalism and internationalism with respect to science was fully on display at the gargantuan international exhibitions of the period. The Great Exhibition of 1851, for example, according to the organizers and the promoters, encouraged *universal* improvement through an international

exchange in ideas. That exchange, however, would take place under cover of direct competition among nations for prestige, medals and honours. In the process, national types were promoted; the notion of distinctive national styles was reinforced. Each country's own patriotism was fluffed and buffed for exposition. Britain celebrated its own national style. The characteristics of other countries were sometimes admired, and sometimes they were ridiculed. But the ever-present overarching idea was that, through all of that competition, civilization *as a whole* was to benefit.⁵ At the same time, however, this was a British version of internationalism. In the liberal politics to which the Exhibition's foundation was tied, that version supported a form of global market that Britain was set to dominate.

Some historians have argued that nationalism as an ideology only first emerged in the late nineteenth century. An influential contemporary examination of the idea was laid out by the controversial French theorist Ernest Renan in his famous 1882 essay 'What is a Nation?'. Renan's definition of a nation rests on a similarly cosmopolitan nationalism: 'Through their various and often opposed powers, nations participate in the common work of civilization; each sounds a note in the great concert of humanity ...'⁶ Renan's understanding of nationality rested upon the shared history and experience of a nation's members: 'More valuable by far than common customs posts and frontiers conforming to strategic ideas is the fact of sharing, in the past, a glorious heritage and regrets, and of having, in the future, [a shared] programme to put into effect, or the fact of having suffered, enjoyed, and hoped together.'⁷ Science, like literature and the arts, sometimes figures strongly in communal perceptions of history; Newton is like an English founding father. The transit enterprise also drew much of its political significance from history. In the nineteenth century, transits of Venus were *already* written into the history books and were *already* a great source national historic pride. This is because the previous transit of Venus, which had occurred in 1769, had been the occasion for Captain James Cook's first travels to the South Pacific, and his first exploration of Australasian lands. In the mid-nineteenth century Cook was probably the most famous explorer in England, and his observations of the transit of Venus in Tahiti were legendary (see for example the epigraph to Chapter 1). In the build-up to the transit of 1874, that sentimentality would influence everything from funding decisions to the blooming of the patriotic rhetoric in the press. And its influence was not just on a public level. For the astronomers involved, as we will see, the history of the previous transit would be enormously important.

According to the *Sydney Morning Herald* article, the important point about the contrasting methodologies of science and politics has to do with progress. Because politicians cannot be made unbiased and impersonal by the application of anything like a 'personal equation', politics will never see anything akin to the

remarkable progress enjoyed by science over the previous three centuries. On the subject of progress in science, the article is exuberant, an attitude that was not at all unusual for the late nineteenth century. Scientific progress was then a given; it was a hallmark of the era. And, with respect to the physical sciences, progress was characterized by precision measurement: the increasingly precise measurements of an increasingly broad range of natural phenomena. In the middle of the nineteenth century the Prussian naturalist Alexander von Humboldt famously predicted that astronomy was reaching its end, having nearly fulfilled its mission of accurately measuring the heavens.⁸ James Clerk Maxwell, though not endorsing that view, acknowledged the widespread perception that ‘the only occupation which will then be left to men of science will be to carry on these measurements to another place of decimals ...’⁹ The transit of Venus enterprise fits the Humboldtian mould of nineteenth-century science like a glove. Its goal was to measure the mean distance to the sun – the value of which is an important standard of measure in astronomy and physics – to a new degree of precision. This depended upon capturing a particular form of extremely precise observations.

In the popular press, the degree of precision required of the observations was often highlighted by dramatic analogies, such as when the *Graphic* of London conveyed the difficulty of the observations by explaining that ‘It is, as *The Times* put it the other day, as if a man standing on the Victoria Tower should endeavour to ascertain the distance of the Albert Memorial in Hyde Park by viewing it successively from the two ends of a twelve-inch ruler.’¹⁰ *The Farmers’ Almanac*, a popular Victorian periodical, put it this way:

Suppose a human hair to be set up a distance of half a mile from the observer, and that the true line of sight passed on the right-hand side of that hair. Now, if by any mischance the observer should observe the left-hand side of the hair instead of the right, that error in calculating the Sun’s distance would make a difference of about a million of miles. Consequently, to obtain the true distance of the Sun within a half million of miles, it is necessary to determine the true line of sight within the breadth of a hair viewed at the distance of a mile.¹¹

Astronomers and the public alike were awed by this measurement challenge. It was a new hurdle for modern science to overcome. On 8–9 December, throughout the collective empire of European nations, scientific progress was celebrated in coverage of the 1874 transit of Venus. But as it turned out, the observations made on that day, a culmination of more than five years of preparation, would never yield an improved measure of the sun’s distance. The transit of Venus enterprise would turn out to be an instance of Humboldtian science that failed to clear the hurdle of precision that had been set for it. A few decades later the transit of Venus was to be remembered most of all (when it was to be remem-

bered at all) for the outstanding *lack* of progress achieved.¹² In this respect the transit enterprise has something in common with the small colonial wars that Britain lost during the nineteenth century. In a century usually characterized as being ‘without major wars’ those minor ones, especially the losing ones, have been leached of historical significance.¹³ The same goes for nineteenth-century science; in a century usually characterized by unprecedented scientific progress, many of the failed experiments, discounted theories and unsuccessful inventions have receded out of sight.

A number of books on the history of the transits of Venus have been published, but in all but one case the focus is on the transit programmes of the eighteenth century, including the voyage of James Cook.¹⁴ With a few important exceptions, the subject of Britain’s nineteenth-century transit enterprise has not been covered in any detail by historians.¹⁵ This is true despite the surge of interest in their histories that came with the return of the transit of Venus in June 2004.

As for the transit programmes outside Britain, a significant amount of work has recently been done on the transit programmes of the United States, France, Germany and Russia. That scholarship has been essential to the writing of this book, enabling crucial comparisons to be made between the British programme and those of other countries.¹⁶ But even with this material to rely on the comparative dimension of this book is not as thorough as it could have been. Sprawling as it is, this book only examines one facet of a much bigger story.

This book is the first detailed narrative of the British transit enterprise in 1874 and 1882 (with the focus on the much larger effort of 1874). The intention, however, is that the value of this history will reach beyond historiographical hole-filling. The hope is also that the narrative will draw attention to the following more general points:

1. That the practices of precision measurement in late Victorian astronomy contain interesting historically specific characteristics, and that those practices reflect an appreciation of the problems and limitations of measurement.
2. That the Admiralty played a key role in shaping the culture and direction of Victorian science.
3. That both ‘big science’ and the (often very closely related) role of science in nationalistic ideology have historical roots extending well into the nineteenth century.
4. That growth in science should be understood separately from progress in science, and that failure in science deserves more attention than it has so far received.

Summary of the Chapters

The book begins with the transit of Venus expeditions of 1761 and 1769. These eighteenth-century transits are linked to those of the nineteenth century in important ways. The transit enterprise of 1874 was a repeat of the nearly identical efforts made in 1761 and 1769. The nineteenth-century politicians, astronomers and journalists saw the 1874 programme as a modernized re-enactment – complete with photography, steam travel and telegraphy – of the historic expeditions. At the same time, the reports from the 1760s would become absolutely central to the preparations for the transit of 1874. So, even while the Victorian astronomers rejected some of the methods used in the 1760s (such as reflecting telescopes for precision observation), they also depended heavily on the results of those methods. In fact the two programmes, although over a century apart, might best be seen as part of a single astronomical enterprise, albeit one that was forced to proceed according to the cosmic timescale of planetary alignments.

Chapter 2 describes the institutional and cultural setting out of which the enterprise of 1874 would emerge. On one level, the scale and cultural significance of the transit must be understood with respect to its status as a ‘pure’ or ‘abstract’ astronomical pursuit. This is closely related to the symbolic value conferred on positional astronomy generally, and on Greenwich in particular, by weight of tradition. The character and operation of Victorian Greenwich under the Astronomer Royal George Biddell Airy, a crucial influence on the development of the programme, will be introduced here. On another level, the transit must be understood as a brand of Victorian military science. In general the ‘big science’ of the nineteenth century was Admiralty science. The transit enterprise is in company with and shares many characteristics of the other ‘big science’ ventures of the time, such as the Magnetic Crusades and the oceanographic expedition of HMS *Challenger*, both of which are also described in this chapter. Many historians (following the claims of Victorian actors) have argued that state funding of science was especially and even strangely weak in the nineteenth century. But, as will be discussed here, when these large-scale Admiralty-funded projects are also taken into consideration, the picture of government science funding at the time becomes more complex.

Chapters 3 through 7 unravel the narrative of the enterprise surrounding the transit of Venus in 1874. Chapter 3 charts the rise of the transit programme in Britain. It began as just one option among many for measuring the sun’s distance proposed by the Astronomer Royal in 1857, but by 1869 it had gained near-universal support among astronomers. This was followed by official parliamentary support. Crucially, during that period, astronomers would begin to re-examine the reports from 1761 and 1769 with the aim of uncovering and correcting suspected errors in the old data. A transit of Mercury in 1868 became an occasion to test

newly-developed theories about how to measure the transit of Venus. And finally, a very public debate between the astronomy writer Richard Anthony Proctor and George Airy brought the subject of the transit into the popular press, where it quickly came to represent a test of national scientific honour.

Chapter 4 investigates the preparations at Greenwich in the build-up to 1874. During the four years between the establishment of the programme and the day of the transit of Venus, Greenwich was the site of time constrained research into a host of unknowns surrounding issues of methodology. This involved investigations into subjects ranging from conductivity in submarine telegraphic wires to the shape of the sun to the properties of photographic emulsions. In the process, Greenwich came to operate more like the private astrophysical observatories of the Victorian grand amateurs, and indeed Airy would enlist the help of some of the most prominent amateur astronomers of the time. Warren De La Rue became the unofficial director of the experimental and controversial photographic plan. By and large the rest of the staff was drawn from the military. George Lyon Tupman, a captain in the Royal Marine Artillery, oversaw all aspects of the preparation. Much of the planning and training was executed with the help of a mechanical model of the transit of Venus. This simulated transit of Venus came to play a crucial role during the preparations, as instruments and observers were calibrated on the model according to a very delicate and specific observational procedure. Internationally, there was very little agreement on methods for observing and recording the transit, and each country ended up with an idiosyncratic plan.

Chapter 5 turns to the expeditions. On 8–9 December, the transit of Venus would be front-page news throughout Europe, North America and the many parts of the globe where there was European-language press. In the coverage in the press, emphasis now shifted from inter-European comparisons to straightforwardly jingoistic celebrations of the expeditions as part of the imperial fabric of the time. In this chapter, the expeditions are explored from the perspective given by the letters and reports of the expedition members. The station at Cairo is taken as a case study, but material is also drawn from the other British expeditions. The chapter follows not only the social and political dynamic of the camp as it was established in the Cairo area, but also details the work routines at the station. This includes the important auxiliary work of finding the latitude and longitude of the stations. Here too, the transit became an occasion to experiment with new methods and to refine the capabilities of old ones – most importantly a new attempt at long-distance telegraphic longitude determination. And finally, at the centre of the entire enterprise are the few hours of the transit of Venus on 8–9 December.

Chapter 6 traces the outcome of the 1874 enterprise. Over the next five years the staff at Greenwich engaged in a protracted struggle with some of the

most imprecise, vague, and problematic data that Greenwich had ever produced. The photographic plates and the observational reports each presented their own challenges, but, essentially, the problem with both forms of data was the same: no matter what analytical tools were used, no certain result could be drawn. Some of the debates about transit methods, especially those concerning the photographic methods, continued to simmer after the transit, finally reaching a resolution towards the end of the 1870s. The unexpected implications of using the simulation transit of Venus also became apparent at this time. During this period, the government's support of the transit programme also declined sharply, and the calculations proceeded under much greater financial pressure than had the preparations or the expeditions. These and other factors combined to hasten a slowly unfolding consensus that the enterprise had been a failure.

The Epilogue covers the transit of Venus programme in 1882. That effort, not surprisingly, was made with less energy, resource and ambition. The preparations only began in late 1880, there were fewer expeditions, and the results were churned out within a relatively short period. But the 1882 programme was not merely a shrunken version of the 1874 enterprise. Different people and institutions were involved, and they employed new modes of management and a revised approach to the challenge of measuring the transit. The very different nature of the transit programme for 1882 underlines certain aspects of both the general failure and certain auxiliary successes of the 1874 enterprise. Some of those changes – especially the more concerted effort at international organization – are evidence of larger, more sustained developments in late nineteenth-century astronomy. Others, like the rejection of photography in 1882, run contrary to the historical trends of the period.