How Science Became Boring: Positional Astronomy in the Nineteenth Century

> The grammarian of the laboratory is often the victim of his trade. He staggers forth from his workshop, where prolonged concentration, on a mechanical task, directed to a provisional and doubtful goal, has dimmed him of his faculties; the glaring motley of the world, bathed in sunlight, dazzles him…
>
> - Sir Walter Alexander Raleigh[1]

> Ah, there's nothing more exciting than science. You get all the fun of sitting still, being quiet, writing down numbers, paying attention...[*chuckles*] Science has it all!
>
> -Principal Seymour Skinner[2]

Introduction

To those not engaged in the practice of scientific observation or telling the story of this enterprise, the thought of empirical research may conjure up images of boredom more than anything else. Long hours spent observing the habits of genetically identical mice, the artefacts of invisible particles, or the slow and patient movement of the stars can hardly bring forth immediate sensations of excitement or pleasure. Neither does the patient accumulation and calculation of data gathered from experiment often stir the imagination. Studies of high school science classes show trouble in attracting student interest, and despite the high praise many in the public have for scientists, they are rarely seen as engaging figures.[3] Specialized journals for science educators are filled with remedies for uninteresting class lessons. Outside of the classroom, few people follow, let alone understand, recent developments in science or even theories fully accepted by the scientific community.[4] The quote from *The Simpson's*, drawn from when the show was both a popular and critical success, is but one piece of evidence that the fundamental position of a great many people towards science, or at least the core activities that comprise empirical research research—'sitting still, writing down numbers, and paying attention'—are met with yawns at best and active unease at worst.[5]

The question of why the practice of science induces boredom both in its practitioners and great segments of its intended public has not received much attention from historians of science.[6] This is curious given its prominence both in the records of historical actors and in popular scientific literature designed to overcome initial concerns about tedious practices. Certainly, debates have taken place over what has defined 'public science,'[7] but few of these have focused on how the seemingly dull aspects of science have been responsible for public disengagement.[8] Other aspects of scientific practice have been studied in depth, from the physical pains endured by scientists to the sometimes odd and absurd devotion of practitioners, but rarely boredom.[9] Surely boredom characterized a great deal of scientific activity and reception, yet it is largely absent from the story of how scientific knowledge is produced. While this lacuna is regrettable, it may not be surprising. The two dominant groups who have written the history of science, scientists and historians of science, have been composed of individuals who take the interestedness of science for granted and consequently, one of this primary features of this history, boredom, goes unnoticed.

Though it is beyond the limits of this paper to explore how boredom manifested itself in multiple forms of scientific research—and the consequences of such boredom both for practitioners and the products of science—some understanding may be gained by examining the development of one particular kind of scientific practice: positional astronomy of the nineteenth century.[10] Positional astronomy in the nineteenth century was a study of boredom in action, and perhaps an ironic one, since the practice of observing the skies had once been considered the most exciting endeavour of the human mind. Astronomy had historically been treated by natural philosophers and intellectuals as the greatest of sciences, not only part of the medieval quadrivium, but an essential part of art, literature and philosophy since antiquity.[11] But in the nineteenth century, in the time between William Herschel's landmark discoveries and the rise of spectrography and astrophysics, the science was characterized by two core activities which had little relationship to the astronomy of old: 1) long and consecutive hours of recording fixed star positions and 2) the tedious and time consuming practice of reducing these observations. Such activities, referred to here as *positional* astronomy, once divorced from the context of the liberal arts, were bound to produce a sense of purposelessness among even the most dedicated observers. Complaints were found not only in the people who did the work of astronomy, but also in the records of those who tried to explain the practice to the public. As these accounts attest, astronomy as practiced in the nineteenth-century professional observatories was at the vanguard of boredom.

To explore this phenomenon, it will require a short introduction into how the practice of positional astronomy in Europe and America developed during the nineteenth century.[12] The increased routinization of observatory practice was the result not only of new forms of mechanical technologies, particularly the chronograph, but also organizational technologies. At the forefront of both of these developments were observatory directors like George Biddell Airy, Adolphe Quetelet, and Simom Newcomb who simultaneously revolutionized the practice of astronomy and imposed a historically unknown level of boredom upon their workers. At the same time, these directors promoted a form of science that failed to capture public attention, leading to a proliferation of superfluous star-catalogues on one hand and amateur popularizations on the other.

A shift in practice and public engagement with science did not happen in isolation. The 'deskilling' of workers, the division of labour in the observatory, and the professionalization of scientific activity were all closely tied to the changing behaviours cultures, and mentalities of populations—a broad and diverse set of changes usually lumped under the imperfect heading of 'modernity.'[13] Yet astronomy as practiced at national observatories cannot be seen as another mere ‘reflection’ or ‘constitutive process’ in a larger movement; it has claim to being a leader. After all, it was in the observatory where the two modern elements of national pride and bureaucratic organization coalesced around the epistemic power of scientific claims. While it might be too much to suggest that the processes and organization of labour developed in the observatory were models for, rather than implementations of, other forms of scientific and bureaucratic structures that arose in the nineteenth century, observatories certainly did not import a system of labour fully-formed outside their walls.

Outside of the observatory, the entire hierarchy of observational practice—directors, assistants, computers, amateurs and ‘the public’—exhibited evidence of increasing boredom. Nineteenth-century European science was characterized by what has variously been called ‘professionalization,’ ‘standardization,’ or ‘specialization,’ when the old eclectic groups of gentleman scientists transformed practice into powerful state-run organizations and the sciences began to differentiate themselves from other forms of intellectual activity (and indeed, from one another).[14] When the phenomenon of professionalization is examined in concert with the scant few attempts that have been made to explain the phenomenon of boredom, there is noticeable overlap. While ‘specialization’ has generally been adopted in reference to how professionals operated, such division of labour and organization extended to the level of the amateur and even the dilettante. As the records of popular works on astronomy testify to the specialization of even amateur work, we can begin to explain why the century saw an increased apathy on the part of the public towards what had once been a source of wonder. Therefore, after investigating the work of observational astronomy, popular presentations of astronomy will be investigated to explain what it was that the public was missing. Most if not all popularisers—including former professional astronomers like Richard Proctor and Jean-Charles Houzeau—professed a hostile vision of the astronomy then practiced in the observatory. Their efforts were in turn treated with laughter and derision by what might be called somewhat anachronistically the ‘scientific community. Central to the process of drawing the line between these groups was whether the material could be made interesting to the general population. When science became boring, it turns out, it also became science.

I begin with background on observational astronomy and the history of boredom itself, the latter of which it seems has a much shorter history. An auspicious coincidence, it was near the time when positional astronomy was becoming the most important scientific practice in Europe and America that the Oxford English Dictionary documented the first usage of a word virtually unknown prior to 1850, but one in full and active circulation today: boredom.

An Old Calling and a New Feeling

Observing and deducing laws from the observation of planets, stars, and other cosmic phenomena has one of the longest and broadest histories of any human activity. The reason for the fascination with the skies is obvious: societies could mark time by the movement of objects in the skies. From culturally important festivals to practically important harvest times, astronomy was central to daily life. Furthermore, the skies were filled with wonders, where imagination, ritual, and theology were inscribed into the celestial world. What we call outer space was for countless cultures the expression of an inner space. Yet as the technical means of observation increased, both perceptions of the sky and forms of communication changed. The great nineteenth-century bibliographer of astronomical works Jean-Charles Houzeau described this transformation, arguing that 'our great modern works, filled with analystic symbols, do not resemble the descriptive cosmologies of the middle ages.'[15] Prior to the middle ages, Houzeau argued, astronomy was constituted by the poems and rich description of antiquity, and prior to that the 'mix of allegory and fables' of 'primitive peoples.' Rather than the internal and consistent record of discovery and the accumulation of knowledge, the history of astronomy for Houzeau was a receptacle of dynamic cultures: astronomy in this vision not only 'advances and recedes with society' but 'is even the history of the human mind.'[16]

Houzeau was neither the first nor last writer to point out that astronomy and cosmology were interrelated.[17] How one viewed the planets was often how one viewed the natural and social world, a feature which did not change during the nineteenth century. Just as Greek fatalism was projected into the skies, and anti-clerical propagandists like Voltaire adopted Copernican and Newtonian metaphors for society, astronomical literature in Houzeau's period mirrored ideas and culture. Nineteenth-century star catalogues, devoid of all information except practical data, developed at the same time as rational accounting procedures, and marked a stark contrast to almanacs of the previous 150 years.[18]

Earlier catalogues—usually called almanacs—had reflected the inclusion of *belle-lettres*, moral philosophy, and essays into public life in the eighteenth century. From 1675 to 1775 American almanacs doubled in size, from an average of 16 pages to 30.86 pages. While essays on moral and political philosophy kept pace with the total number of pages, the amount of tabular information skyrocketed, from an average of 1 page per almanac to nearly 12, growing from 6.7% of the pages to more than a third.[19] Until 1783, an eclectic almanac could still include articles on 'A Receipt for Making very good INK,' 'Thoughts on Happiness,' and a moral lesson on the 'True Greatness in Henry IV of France,' but the tables of data were beginning to take over at the beginning of the century.[20] These eclectic almanacs, whose tables were riddled with errors and inconsistencies, were still valuable —America had no observatory and farmers did not require detailed star positions, only general guides to astronomical and meteorological activity. Yet the revolution in observing practices in the nineteenth century would make such almanacs, and their asides on politics, history and humour, obsolete.

The revolution in astronomical practice resulted from the techniques developed by Gauss for determining star positions and the subsequent stabilization of the skies envisioned by place. **(One sentence on Gauss – More on Laplace)** *Mécanique Céleste* and *Système du Monde* set the agenda for how positional astronomy would operate. Even as late as 1789 De Fontanes could write a famous ode to the practice of astronomy, invoking observation as the 'glory of the arts,' but in the wake of Laplace's forceful demonstrations of planetary movement, observatories soon reconfigured themselves for the exacting task of charting the position of all of the background stars.[21] After the probabilistic revolution, the practice of positional astronomy lost its literary and romantic allure and disentangled itself from history and culture: it had become a serious business.[22]

Such a change in the approach towards science was neither accidental nor dependent upon the ontological status of heavenly bodies. In England especially, the changing practice of astronomy had much more to do with practical concerns of good sense than actually unlocking the secrets of the stars. Babbage was certainly not alone when he famously complained in 1830 of the 'Decline of Science.' Claiming the support of his friends, the eminent scientists Humphrey Davy and John Herschel, Babbage attacked the institutions of the time for 'the indiscriminate admission of every candidate,' to the Royal Society, an infraction 'so notorious' that it was 'beyond the pale.'[23] In England, the system of laisse-faire funding for research projects had left them behind other nations of Europe. In short, he argued, 'the pursuit of science does not…constitute a true profession.'[24] The old-fashioned clubs and societies, funded by independently wealthy contributors, may have worked in the past, but the sciences had reached the point where each new discovery was requiring a greater expenditure of effort and resources. Chalkboard mathematics and simple experiments would no longer suffice. Greater advances towards 'accuracy' and 'precision' required a greater devotion of 'time, labour, and expense.'[25] Herschel may have put the point better, at least from the perspective of the researcher: 'Science is much indebted to such men, by whose quiet and unostentatious labours the routine of its institutions is carried on.'[26] Though the case would be markedly different in Europe by the end of the nineteenth century, even as late as 1847 the complaint was made that science was 'in a wretched state of depression…owing (to)…their exclusion from honours of state.'[27] National observatories, it was suggested, could provide the solution to this problem, and at the same time provide a place for ‘unostentatious labour.’

While Babbage’s grumbling may have reflected a genuine belief, historians have found that scientific practice in England was already becoming more efficient at the time that Babbage lodged his complaint.[28] While the transformation of practice spread throughout all the branches of science, it was particularly strong in astronomy, which was experiencing tremendous growth both in efficiency and state support, the two weaknesses cited by Babbage.[29] Indeed, by the end of the century the American astronomer Simon Newcomb could claim that ‘a feature of London life...is the closeness of touch, socially as well as officially, between the…scientific classes on the one hand…and the governing classes on the other.’[30] By the end of the century, science in England could no longer be marred by easy admittances or lack of organization.

Changes in nineteenth-century practice were intricately tied to changes in culture and practice far removed from the observatory. The observatory did not develop according to coherent internal conception of what constituted a scientific method, but rather reflected the values of the societies that built and paid for them. Varying claims have set the ‘model’ for the observatory as the industrial factory, the accounting office, or the corporation, but all have agreed that directors like Airy, de Verrier, and Pickering consciously adopted the structure of successful institutions for their observatories.[31] While there was no question that directors made reference to other forms of large-scale employment, it might be better for now to imagine the nineteenth-century observatory as emerging from the same milieu as the factory, accounting office, or corporation, rather than a degree removed. All were based on the same set of organizing principles, and the ‘science’ of organization would seem to lend itself best to a research centre for natural observation before it would a factory. In any case, while it is important to separate out the difference as to whether observatories looked like assembly-lines or boardrooms, for the purposes of the workers themselves, the resulting situation was much the same: the work became far less interesting.

The 'boredom' that entered into both the English language and astronomy around 1850 had precedents. Though variations on the verb 'to bore' had existed for over a hundred years, most English writers and speakers were forced to rely on the inadequate *ennui* to describe a state of being, which too many connoted a from a restlessness more than uninterest. And while 'boredom' itself was absent, the concept was certainly appreciated. Byron, for one, complained about the absence of an English equivalent to *ennui* by the beginning of the century.[32] Nor were concerns about what we might call boredom or tedium new to cultural observers. The Greeks complained of *accidie* and the Romans *taedium*. Indeed Pascal, certainly no modern, authored one of the better treatments of *ennui*.[33] Yet, as cultural historians have investigated the term, they have been in agreement that boredom experienced since the nineteenth century was of a different order than its linguistic ancestors and that the affliction, whatever its name, has not begun to affect large numbers until the last 150 years.[3034]

The simultaneous introduction of positional astronomy and boredom into nineteenth-century culture was not a coincidence. Indeed, the following description of modern boredom could easily be applied to astronomical workers at the same time:

> It is not difficult to establish that there was one characteristic common to all instances of boredom, present and past, namely the loss of a sense of personal meaning, whether in relation to a particular experience or encounter, or to an entire life-situation. This loss might be occasioned by the withdrawal or absence of the meaningful, or by the imposition of the unmeaningful.[35]

As will be seen in the portrait of observatory worker, 'personal meaning' was indeed lost in the process of observation and calculation, and intentionally so at the behest of observatory directors, who imposed self-consciously 'unmeaningful' work on their employees. At the same time, individuals, with the exception of a few navigators and a handful of other actors who derived a functional meaning from the new research, experienced the loss of a sky relevant to everyday experience. As Adolphe Quetelet, director of the Observatoire Royale in Brussels wrote, 'people have ceased to make calendars for themselves…they have ceased to be able to even appreciate the service that is given them.'[36] With the skies no longer a place for poetic contemplation or religious meaning, interest waned.

Before examining the practice of observatory workers, it should be pointed out that not everyone involved in astronomy at the time was subject to the routinization and specialization of work. There were two notable exceptions. The first were observatory directors themselves. While famously sober men like Airy rarely left the observatory computing room, many observatory directors were able to travel to exotic lands in support of their position. At Paris, for example, the observatory was also the home of surveying explorations which allowed astronomers Delambre and Méchain to get outside of the cramped quarters of the observatory to discover the 'true' meter. In Europe and America, the Transit of Venus observations sent directors around the globe. In Belgium, both Quetelet and Houzeau travelled the world, with Quetelet visiting Germany, Italy, and Paris before his observatory was even built, and Houzeau taking a detour from observatory life to set up an abolitionist newspaper in New Orleans.[40]

The other group who largely avoided the tedium of modern astronomical work was what Chapman has called the 'grand amateurs,' a loosely collected group of independent wealthy astronomers in England. While men like Herschel certainly contributed much to what became accepted astronomical knowledge in the nineteenth century, it was a last gasp prior to the era of astrophysics which required both expensive equipment and an army of employees. By the beginning of the twentieth-century, even manuals promoting amateur astronomy admitted that they were in a subservient position.[37]

Outside of wealthy amateurs and well-connected observatory directors, the act of scientific research and the presentations of its conclusions became increasingly dull as the century wore on. Not only did *Eléments* of practical instruction begin to dominate astronomical publications, but star-charts and ephemerides replaced the more wide-ranging and colourful almanacs of the eighteenth century as the primary means of dissemination. The collection and distribution of the information at the heart of positional astronomy was, for many if not most of the men and women who laboured in the observatory and consumed **(BETTER)**

Bored Workers: Useless Data, Vigilant Surveillance, and the 'Idiots' of the Observatory

In the nineteenth century, there was no more revered institution in the scientific hierarchy than the observatory. Between 1810 and 1910, the number of European and American observatories increased seven-fold, from 31 to 234.[38] Observatories were built at a frantic pace in Germany, England, Belgium and Scandinavia often more for reasons of prestige than scientific advancement.[39] John Quincy Adams was only following a pattern first established in Europe when he lamented that there was not a single observatory in the Western hemisphere while there were '130 of these light-houses of the sky' in Europe.[40] In England, astronomy became the second discipline to form a formal society while in Belgium, Adolphe Quetelet pleaded for eight years before an observatory was built, claiming everything from scientific necessity to national defence.[41] Observatories stood not only for precision, accuracy, and the progress of science; they were also sources of national pride, paid for by state governments and given dedications by leaders and kings alike. While funding and staffing differed across nations, the observatory was held in similar regard from St. Petersburg to Dublin to Washington, D.C.[42] And while their primary task was to observe and chart the star positions for navigational purposes, observatories also conducted research into metrological events, terrestrial magnetism, plant life, and surveying. They were drivers of scientific practice, essential to research universities, and the physical embodiment of the new idea of order, accuracy, and precision in science.

Despite such acclaim the observatory was not always an ideal place to work. The nineteenth century is filled with examples of rotting buildings like the Link Observatory in California.[43] Worse, some places had little to no working equipment, such as James South's Campden Hill observatory where 'the meridian makes apparently every star a planet,' and where South complained that he had not conducted a 'single astronomical observation' in seven years.[44] The Armagh Observatory could top even that, with 'no work of any real value' taking place from 1793 until 1828.[45] Primate Robinson, who directed the observatory during its lean years, could claim several excuses, however. From the train terminus located 700 yards away that shook his instruments to the clouding of his telescopes from chimney smoke of the near-by town, the lack of accurate observations was not surprising. Even in 1880, after many of the problems related to instruments had been fixed, the Smithsonian Institute issued a scathing attack on the state of America's observatories.[46]

Such problems may have plagued observatory directors, but the boredom involved making incorrect observations and measurements with outdated and flawed equipment paled in comparison to the work involved in making *correct* observations. At the major observatories charged with producing accurate star charts like Greenwich and Washington, the problem was certainly not a lack of work to be performed. Observatory directors who wanted to produce authoritative catalogues and who had adopted Airy's system faced what Ian Hacking has called an 'avalanche of numbers' both from their own research as well as other observatories.[47] Thousands of stars had been observed using flawed equipment, or had simply not been reduced, and many directors took it as their mission to work through the backlog. If such an incredible amount of data were to be gathered and sorted, however, it would require a team of regimented observers and computers. Unlike the troubled observatories of Link and Armagh, there was much work to be done.

One of the most important elements of sifting through the avalanche was to establish uniformity in observational practice, the goal of the many *Éléments* Houzeau cited. Yet standardization went beyond simple training. Almost as important in standardizing practice was calculating an individual observer's 'personal equation.' No matter how well trained, directors found that there existed individual tendencies that caused observations to differ between two observers, even after hundreds of trials. Try as they might, directors were unable to overcome the stubborn differences that existed in their employees. Though the first man to discover the personal equation promptly fired his assistant, it was soon realized that the personal equation could be accounted for and later factored into reducing the figure. If they could not normalize the observers prior to the observations, the math would enforce standardization afterwards. Such determinations required hundreds of 'mock' observations, where the practice of observing the skies was simulated and observers practiced 'seeing' and reporting. Before they were given the opportunity to spend hours marking the positions of actual stars, it required days and sometimes months of recording fake ones.[48]

The personal equation remained even as the practice of observing changed dramatically in the nineteenth century.[49] Until Airy had implemented the use of the chronograph in the 1830s, the observer needed to both 1) watch for a given star to bisect a micrometer and 2) listen to a clock to mark the time. Sometimes he would have an assistant to 'call' the sighting, but often it involved tracking both sight and sound, several times per hour. Even with the chronograph, which standardized observers to the point where they need only make a simple mark when they saw the star, observers still needed to be calibrated.

The process of recording observations changed dramatically during the nineteenth century but it retained an essential qualification: patience. As Schaffer described the practice, 'the managers of the great observatories' required a 'regime of vigilant surveillance of subordinate observers,' to make the ceaseless observations.[5062] In some observatories, directors instituted round-the-clock observations which required staggering feats of endurance. At the Washington Naval Observatory, four assistants were called on to monitor the mural and transit in steady cycles, requiring shifts from nine in the morning until 'midnight or even the dawn of the next morning.'[51] The work was not merely supervisory; depending on the season and the clarity of the skies, assistants had to make up to several dozen accurate observations per hour. One simple mistake could ruin the evening's data. Such a routine, the director Newcomb noted (with approval) 'was certainly a departure from the free and easy way in which we had been proceeding.'[52]

Observatory directors rarely performed such tiresome work themselves. Bessel and Airy, perhaps the two most respected observatory directors of the time, never looked through a telescope or completed a calculation. At times, assistants would take over, but at the largest observatories, the observer's status was the equivalent of an entry-level position. 'The lowest of all employments in the Observatory is mere observation,' Airy claimed, 'No intellect and very little skill are required for it. An idiot with a few days practice may observe very well.'[53] As historians have noted, the practice of astronomy had inverted since the days when Galileo used observational records to argue against speculative theory: in the nineteenth century, the people actually watching and tracing the movement of the stars had very little to say. Praise and recognition was instead reserved for those who theorized about the heavens and organized their exploration. Furthermore, the production and creation of instruments themselves had been outsourced, so that few observers or directors had any relationship with their equipment prior to its delivery.[54] So powerful had the organizing principle become that by the end of the nineteenth century some astronomers were even cautioning against the model set by Airy. While 'doubtless useful,' the editors of *The Observatory* worried the strict division of labour was problematic for creating new ideas: 'there is…no greater danger than that of drifting into routine in the case of an advancing science.'[55] However, as any director at the time well knew, Airy had proved that 'drifting into routine' was the most direct path to success in positional astronomy.

While the day-to-day routine of the average observer was the engine powering the observatory's production of data, the resulting product—accurate and reliable star catalogues—required another class of labourers: computers. As one catalogue put the matter, 'astronomy is the science where one encounters the most frequent occasions to make long and complicated calculations.'[56] In the language of astronomers, 'figures were cheap,' and observatories distinguished themselves not through the raw data of observation, but the finely tuned numbers they published.[57] This had not always been the case—in previous centuries the worth of an observer was determined by how well they calibrated their instruments in preparation for observing, not how well they manipulated the data afterwards. The great bulk of labour was done *prior* to looking through the lens. Yet as the mathematics behind reducing large numbers to averages was being completed by Gauss and Laplace, observatory directors realized that all of the work could be back loaded. Not only could all of the messy details of individual personality and equipment error be corrected for, but great piles of information previously considered useless could be given meaning. In the hands of able computers, error could be made fact.

As one director explained his effort to reduce thousands of observations once thought worthless: 'these valuable observations have so long remained in the crude state of ore, without any known attempts to extract the precious metal which they contain.'[58] Like any mining expedition, data or otherwise, the actual work of 'extraction' required a great deal of labour. Here again Airy provided a new model. After taking over at Greenwich, he had radically overhauled the hierarchy by hiring relatively untrained workers and providing them with 'skeleton forms' which would essentially do the work of computing for them. The calculators need only enter the raw observation data, perform a few simple arithmetic calculations, and the corrected number would appear. This is not to say Airy had little work to do, only that he rarely spent time with the calculators in what he called the 'most pitiful little room.'[59] In fact Aubin has claimed that calculation itself had very little to do with scientific recognition at the time: directors 'won prizes and medals…not because of their computations but for the ingenious ways they devised avoiding them.'[60] Yet despite rarely engaging in actual observation or calculation, it was Airy rather than his assistants who was considered the astronomer.

Such computations were valued even when the original data was in a wretched state, as when the British Association for the Advancement of the Science published a catalogue of reductions for 9766 stars observed a hundred years prior made with only a 26 ½ inch telescope. There was no question as to their potential utility—they were made from the Cape of Good Hope and provided rare data on the southern hemisphere—but the observations themselves were chaotic, believed to be 'completely useless' for a century.[61] The major problem was that they had been made using 'an instrument so defective in optical power,' and with 'no greater exactness (even) in noting the movement of ingress and egress (of stars).' As Herschel admitted, 'much precision was not to be expected.' Nevertheless, the Astronomical Society had declared in 1838 the necessity of reduction, and with Herschel and Francis Bailly forming the committee, the task fell upon lesser lights to produce the actual volumes. Though some observations may have been off by up to 30 degrees, the panel concluded that 'it appeared desirable that the whole should be reduced on an uniform system.'[62] Further complicated by the death of Bailly and one of his assistants during the process of reduction, the catalogue was still able to be published nine years later. **(Transition LUFF)**

The result of all this labour was hardly a product worth getting excited about. The star catalogues that resulted were little more than pages of repetitive data, a departure from earlier almanacs. Pictures were scarce, and rich descriptions of phenomenon nonexistent. So dry were these products that Herschel was actually commended for 'cloth(ing) the description of so boring a thing as a Catalogue of stars with the amities of human interest and the guises of poetic elegance.'[63] Even the functional value of the majority of the catalogues could be questioned. As Newcomb wrote, all

> …the leading nations publish ephemerides of this sort. The introductions and explanations are, of course, in the languages of the respective countries; but the contents of the volume are now so much alike that the duplication of the work involved in preparing them seems quite unnecessary. Yet, national pride and emulation will probably continue it for some time to come.[64]

As publisher of the leading National Almanac, Newcomb had good reason to disparage other efforts, but his point was sound. There was no need for each country, let alone every single operating observatory, to publish their own catalogues when Greenwich and Washington offered the most accurate figures. Especially given the tremendous effort of observers and calculators alike, it would have been more than a simple waste of numbers; it was a waste of workers' time. Yet Newcomb offered no suggestion as to what else observatories should dedicate their time. After all, if observatories were to eliminate their own publications, they might have faced a question more profound than national pride. What else, exactly, were they there to do?

Several important questions arise from cataloguing the hierarchy of boredom in the observatory. Primarily: who were the astronomers? Was it the 'idiots' who could pick up the task of observing in a few days and did little more than make marks on paper? Was it the computers, whose task could be performed without ever looking up from their table of functions and calculation? One might be tempted to claim that it was the director's themselves, yet this was far from certain to contemporaries. 'The Director of a Government Observatory is in fact not solely an astronomer,' one such director wrote. 'We might even say he is not an astronomer in the first instance.'[65] Furthermore, what was the experience like for the people who worked at the tasks of observing and computing, for the people who laboured for hours on end at repetitive tasks to create redundant books filled with useless numbers?

While some like Mr. Luff are occasionally mentioned, few are given a portrait other than to say they were 'hard workers' or 'zealous in their task.' Their labours reveal themselves only in the thousands of pages of superfluous catalogues.

Finally, this portrait of observatory work should not be taken to indicate that the work conducted at places like Greenwich and the National Observatory in Washington was the only method. Other directors took different approaches, denying a strict division of labour and repetitive tasks in favour of promoting the spirits of their workers. Presenting his conclusions to *The Observatory*, Chandler praised his work at the Dudley Observatory in Boston as the result of a process very different from Airy's. His catalogue, he claimed, 'could hardly have been reached so effectively by a formal organization of work, directed from headquarters, prescribing and circumscribing the operation of each participant.' Such a model, Chandler argued, '(destroys), by its benumbing influence, the enthusiasm which springs from the individual imitative of the observers themselves.' [66] Chandler's decentralized approach, while possibly lightening the boredom of his workers, was not suited to success in nineteenth-century positional astronomy. After all, Greenwich was the model observatory in the world while Dudley was the producer of just one more meaningless star chart.

Bored Readers: The 'Paradox' of Public Science

The computers and observers of the large observatory were not alone in finding the new positional astronomy tedious. To judge by astronomers' efforts to spread the knowledge of their subject to a broader populace, the public was also growing bored with the professional accounting of the heavens, turning their attention instead to the occult or other more interesting explanations for natural phenomena. In 1882 the *Vade-Mecum* listed 38 relevant works on astronomy intended for public consumption, ranging from instructions for '*jeunes dames*' to more advanced amateurs. The literature of the late nineteenth-century was full of appeals to the 'general student' of the sciences, but appeared to do little to direct attention towards science as practised in the observatories. Despite all the publications, the complaints and the concerns of popularisers remained throughout the century, indicating that the product of observational astronomy held little more interest than its production.

In 1797, Alexander Ewing stated what he called a 'paradox' of the progress of astronomy: 'the discoveries and improvements made in Astronomy during the last 40 years, instead of primping study, have had a contrary effect.'[67] In his mind, the larger public was turning away from astronomy at great detriment to the science as a whole. 'Although great discoveries and improvements have been made in astronomy,' Ewing wrote, 'the science is still possessed by a small number of persons.' In the late eighteenth century this was still considered a problem, and Ewing's goal in writing a book intended for the public was not education for its own sake, or even for the development of the reader's mind, but simply to advance knowledge: 'To make the most of any art or science for the benefit of mankind, it is necessary that many people understand it…' Two hundred years later, few would agree with such a pronouncement, yet Ewing, like many of his contemporaries, was steadfast in believing that the integration of the public with the science of astronomy was mutually beneficial. It was a stance that was to gradually lose supporters.

Astronomers and observatory directors initially desired public assent and support. In some cases, cultivating public interest was pragmatic, as in the case of O.M Mitchel's lectures to the citizens of Cincinnati on the need for an observatory. As Mitchel told his audiences of both well-connected fundraisers and a voting populace 'the future scientific character of the country rested with the people.'[68] The great historian Agnes Clerke believed 'the new physical astronomy depends for its prosperity upon the favour of the multitude.'[69] The 'favour' of the public was not limited to material support however; several authors believed that research itself depended upon a knowledgeable public.

Ewing compared public instruction in astronomy to accounting: ‘About 400 years ago there were fewer good accountants in Britain than there are astronomers at this day.’[70] [3](**BUSINESS OF ASTRONOMY-Relate to astronomy)**[3, 1171] Even Airy thought the public could appreciate the work of his observers and calculators at Greenwich, including a brief article in the Penny Cyclopaedia on ‘Gravitation.’ In a longer work on the same subject, he was explicit that the great theories could be grasped by everyone. Popular astronomy, he argued, should ‘not be restricted to the instruction of readers who are unable to pursue them with the powers of modern analysis.’[72]

‘Modern analysis’ (mathematics) remained a problem however, and authors throughout the century grappled with how best to present the results of a profession more concerned with calculation and standardization of error than rich description of phenomena. One publication claimed it was impossible to teach too much since ‘the average man draws the line at what mathematical knowledge should be expected of him at some relatively early stage.’[73] The author of a popular work entitled *Heroes of Science* even conceded that while he would avoid any equations, math was ‘the one key that would unlock its mysteries.’[74]

How could a science that was becoming quantitative still be understood by a general reader? One populariser, offering his own work as a solution, complained that by 1867, there was still no work in the English language which was ‘attractive to the general reader, serviceable to the student, and handy for purposes of reference.’ Not only could authors seemingly no longer write for a wide range of readers, but it was hard to find ‘works which are popular without being vapid, and scientific without being unduly technical.’[75] Chambers did his best to make the material interesting, including informing his readers that ‘the direct light of the sun (was) equal to that of 5563 wax candles of moderate size placed at a distance of one foot.’ On comets, Chambers quoted the contemporary poet Brayley in attempting to render the objects of the sky in a way that would have seemed natural one hundred years before: ‘The blazing star, Threat’ning the world with famine, plague, and War.’ Chambers’ *A*

Handbook of Descriptive Astronomy went through several editions, proving that astronomy could sell, but it was mostly limited to those who were already attracted to the subject. The key at least for Chambers was 'preferring fact to fancies' and avoiding all theoretical discussions: 'those mischievous speculations on matters belonging to the domain of Recondite Wisdom.'[76] It also helped that he did not use many numbers.

The problem of teaching a subject so tied to quantitative techniques baffled even one of the most able, and certainly one of the least boring, astronomers of the nineteenth century: Jean-Francois Arago. In *Astronomie Populaire*, Arago took a different approach from Chambers, insisting that the theory of astronomy—the 'mischievous speculation'—should 'precede' any discussion of true astronomy. The theoretical basis would replace mathematics, which few in his audience would have understood and which was anyway unsuited to a public lecture. Replacing mathematics with descriptive accounts of the physical theories of motion may have made the work a little easier but did little to make it more exciting, a problem Arago recognized when he apologized for beginning with the most challenging subject: 'I pray the reader will pardon me for the dryness of this debut.'[77] *L'aridité* continued throughout the lectures, however, where Arago warned his students that there will be a lot of 'repetitions,' but that 'this inconvenience cannot be avoided.'[78] Though the class upon which *Astronomie Populaire* was based had lasted for thirteen years, Arago had doubts about its effectiveness. He had enjoyed teaching the class, but was concerned that it might have to be discontinued. Of the fifteen members of the *Bureau des Longitudes*, which required public instruction from one of its members, Arago had been the only person willing to teach the required class. The objection from his colleagues was simple: 'these eminent men maintain that this science cannot be taught to those who do not already understand mathematics.'[79] By the mid nineteenth-century professional astronomers were following Arago's colleagues, producing textbooks for practicing observers and abandoning the public.

While Arago and others were able to maintain classes for several years, the efforts of nineteenth-century professional popularisers can only be seen as failures. By the end of the century, few scientists maintained an interest in presenting the latest information in any sort of public form. Specialized journals had supplanted the *Grandes Ouvrages Didactiques* that had once allowed an interested outsider to learn the most important discoveries in astronomy. Worse still, popular astronomy became fodder for jokes. The pages of professional journals were filled with accounts of an uninformed public. One writer was mocked for claiming that a person who jumped from a cliff would have their weight double every yard.[80] Another story told of a teacher who had abandoned astronomy as a subject because one girl in her class had held 'the zodiac' responsible for the bursting of a steam-pipe.[81] Worst of all, even educated men did not seem immune. One anecdote, which elicited both humour and horror from the teller, concerned two Austrian military officials who were discussing the possibility that a hot-air balloon could reach Mars. Such foolishness was bad enough, but made worse when a lieutenant-field-marshal interrupted to argue that it was 'only that our *technical means* would not yet suffice to give the necessary size to the balloon.'[82] If even basic concepts of astronomy could not be understood by high ranking government officials, what hope did the popularisers have.

A near abandonment of the project of professional astronomers to provoke interest in the general public—the necessity that had guided Ewing's work—was at hand by the close of the century. In 1895, in an interview given to the San Francisco Examiner, the director of the Link Observatory E.E. Barnard expressed the waning hopes that the newspaper-reading public would follow astronomy the way they followed 'prize-fighting and horse-racing.' 'I believe that people who ordinarily are supposed to only appreciate such reading matter in the daily papers…will be found to be deeply interested in astronomical subject.' Unfortunately, Barnard's solution was to present the findings of astronomers in 'an easily intelligible form,' a plan that had been unpersuasive in the past. Reviewed in the *The Observatory*, Barnard's comments provided only mild amusement to the editors, who claimed that astronomy was just not that sort of thing. Unlike other activities, which offered ‘new developments’ every day, astronomy was only advanced over long periods of time, and therefore inadequate for newspapers.[83] A public engagement in scientific theory and practice—the requirement for Ewing, Clerke and others—had become an impossibility.

No ‘Bizarre Contradiction’: Why Science Became Boring

When professional astronomers gave up trying to capture the attention of the public, authors not attached to observatories were happy to provide a substitute. Popularizations of astronomy that had once been the province of observatory astronomers like Arago and Airy were taken over by amateurs, historians, and former observatory workers. These works, while distinct enough to avoid any but the broadest generalization, did share three common characteristics. Primarily they excluded references to any math or mechanical theory. In their place, popularisers employed a variety of rhetorical strategies—poetry, astrology, ancient myths, and divine explanation— that while once part of astronomical discourse had been expunged in the creation of star catalogues. Thirdly, popular works on astronomy also explicitly condemned the observatory model of positional astronomy as anti-scientific. National observatories in this account became merely chroniclers of useful data, often dismissed as relevant for ‘commerce’ but little else. While these sold well and provided exciting stories to an eager audience, they had little success in penetrating the boundaries of professional astronomy. Each group was now speaking only to themselves, and as the twentieth-century growth in large-scale research astronomy—what Gallison called ‘big science’—would demonstrate, only one succeeded in claiming the title of science.[84]

The most successful and controversial of popular expositors was Richard Proctor, a former member of the Royal Astronomy Society who turned to popular writing after a bank failure caused him to look for a more lucrative relationship to astronomy. Proctor's approach, which served him well over the course of dozens of books, hundreds of articles, and thousands of lectures, was that 'a general public could not be attracted by writing which required a prolonged effort of reasoning or study to understand.'[85] Exercises in complicated reasoning, the goal of Arago, Airy and others, was replaced by what Proctor called 'contemplation of a scene so magnificent.' It was an anti-quantitative theory which explicitly rejected the techniques that had been employed in positional astronomy:

> A man may have at his fingers' ends the distances, volumes, and densities of all the planets, the rates at which they move…and a hundred other facts equally important in astronomy; but, unless he has in his mind's eye a picture of the solar system, with all its wonderful variety, and all its yet more amazing vitality, he has not yet passed even the threshold of the science.[86]

Nowhere in the star catalogues and *Éléments*, Proctor argued, could one find a description of 'wonderful variety,' only 'distances, volumes and densities.' His alternative to professional astronomy not only lacked much in the way of quantification, it even claimed murals and transits were not necessary: the naked eye could appreciate astronomy 'without optical instruments of any sort.' Quantification and technological advances could certainly make astronomy more 'useful,' but this instrumentality was beside the point. The great astronomers like Galileo and Copernicus, Proctor argued, had only made 'accidental' advances in 'practical astronomy'; their true genius lay in what he called 'understanding.' Astronomy, rather than a useful tool for generating practical information, was 'a subject for study and contemplation…for ennobling and purifying the mind.' The professional astronomer, whom he derisively labelled the 'astronomical surveyor,' was necessary to generate important information but he should not be confused into thinking he was practicing true science. Contrasting the great astronomers of the past with the observatory directors of the present, he argued that ‘the stupendous celestial mechanism, the beauty and harmony of the celestial architecture, is not for the Flamsteeds, the Maskelynes, and the Airys.’ To this group ‘commerce owes much,’ but ‘scarcely any…value’ in astronomy was the result of their labours.[87]

The popular success of Proctor’s works indicated that professional astronomers and the ‘general reader’ were looking at the skies very differently, the former as a place to be divided and quantified in service of accurate star-charts for navigation and surveying, the latter as a source of inspiration. While such a divide may have seemed inevitable, prior to the nineteenth century astronomy had been able to straddle the line between functionality and inspiration, or between what we might today recognize as science and art. Poets spoke of astronomy more than observatory directors, and while most of the public did not read Laplace and Newton, the theories themselves were appreciable to people without specialized training through the work of the *philosophes* and other propagandists for new cosmologies. Furthermore, as several historians have argued, scientific demonstration and experimental confirmation were themselves dependent on public discussion and assent.[88]

The Enlightenment approach to explaining science, intended as means to convince authorities of the cultural and epistemological power of science, was so successful however that a century after their efforts scientists no longer needed the public. The seeming paradox identified by Ewing in 1797, that the sciences progressed at the same time the public removed themselves from the proceedings, was by the twentieth century no paradox at all. Not only did advances in practical astronomy take hold in spite of rapt public attention, they took place *because* the public had lost interest. As Robert Woodhouse put it is his own introduction to astronomy, any work worth the name of science should ignore the elements most interesting to the public. Such speculations could only ‘divert the attention of the student’ away from ‘real inventions’ and towards ‘foreign, fanciful, and antiquated’ theories.[89] He argued that progress could only be made ‘by detailing and explaining the best methods’ even though ‘the details’ were 'very tedious.'[90] For his own *Élément*, Woodhouse proposed only to describe practice—the day-to-day techniques of observers—and eliminate all references to history or theory, what he called 'methods merely curious and of no practical utility.' There was no point in referencing even Tycho Brahe or Ptolemy, because 'the spirit of defending' those practices was 'extinct.'[91] Even Proctor agreed that work in the observatory was incommensurate with an appreciation of the history of astronomy or its cultural influence: 'the astronomical surveyor must work unmoored by [historical contemplation], or he will scarcely work in an effective manner.'[92]

The move away from history and other 'merely curious' methods of appreciating astronomy may have been the single biggest reason positional astronomy lost the public imagination. Even Arago may have hurt his own cause, and the cause of those who wished astronomy to be a 'universal subject,' by severely limiting the variety of approaches that could be entertained. Such 'foreign ornaments'—his term for the history of astronomy and its place in literature and culture—Arago deemed unnecessary. Instead, a 'true' appreciation of the science could be found in understanding 'rigor, the clarity of the methods of investigation, and the magnificence and utility of the results.'[93] Prior to Arago, the great astronomer Biot proposed a similar plan for public instruction, arguing in his highly influential *Traité Élémentaire* for a form of instruction for 'the student with absolutely no knowledge of astronomy.' The first step, like that of Woodhouse and Arago, was to 'disengage the student from his prejudices.' Then, 'little-by-little' the freed student would 'through reason…find for himself…the true mechanism of the system of the world.'[94] Wonder and awe, the kind of rapt contemplation prescribed by Proctor and championed by poets and astronomers alike, was to be replaced by a great puzzle. The 'system of the world,' Biot argued, 'envisioned in this world becomes a great problem of physics' instead of a mystery. It should have been no surprise the public was bored: how many readers would opt to solve a physics problem over reading a great mystery?[95]

Biot, like Ewing, observed that there was a 'bizarre contradiction' in astronomy between its success as practice and its reception in the general public. The field was after all making progress at an extraordinary rate, and the scope of 'the oldest and most perfect' of the sciences had been extended. Somehow, however, Biot felt it 'had not yet been introduced in the first instances in public instruction.' Biot's multiple-volume solution to this 'gap' may indeed have been a part of the problem. By positioning astronomy as a problem in physics for the public, he emptied the discipline of other approaches. For a century after Biot wrote, in fact, the popularisers that had the most success in relieving public boredom knew well not to turn planetary and stellar movement into a solvable puzzle.

Was there a solution to the paradox proposed by Ewing? Was there a way to untangle the contradiction and tie the public imagination to the professional pursuit of the sciences? Could astronomy 'work' and be interesting at the same time? Based on the debate between successful popularizers and professional astronomers, it seems unlikely. While Proctor had attracted a large public following with illustrative works on astronomy, the field was not going to make much progress in creating accurate star charts based on a philosophy that held optical instruments as optional. Conversely, the textbooks and *Éléments* that were successful in training professional observers and navigators were almost apologetic in the fact that their products were 'tedious' and 'uninteresting.' Grand visionaries like Mitchel may have tried to elevate astronomy to theology, but why would a religious public substitute an observatory for the church they already had? The course of astronomy and other sciences, which all maintained a similar 'paradox' of professional interest and public boredom, suggest it may have been impossible. To emerge from the nineteenth century with professional boundaries intact, science had to sacrifice public interest.

Conclusion – Transcending Boredom

Astronomical literature fragmented at the end of the nineteenth century. While never fully homogeneous, no *Vade-Mecum* of astronomy covering the works produced at the turn of the century could hardly have justified including the writings of Proctor alongside the practical instruction books of Chambers. *Astronomie Populaire* was a title fit for canonical inclusion when used by writers like Arago and Quetelet, but not when adopted by Flammarion. While astronomers in the beginning of the century like Ewing and Biot had held out hope for a science that could attract both public and professional attention, professional astronomers by the end of the century had give up such hopes. Not only did the precise and time-consuming work of observational astronomy bore public audiences, the resulting products of this work—star catalogues and ephemerides—were self-consciously arid documents. Instead of following the daily progress of positional astronomy in newspapers, audiences found a diverse array of popularizations whose work was ignored or mocked by the professionals. The work that could interest public and practitioner alike was no longer possible. Normative philosophies of science once claimed scientific practice was epistemologically sound because of a lack of bias on the part of its practitioners, a naïve view rarely held today even among scientists.[96] Yet such philosophies may have been close: scientific progress required not *dis*interest but *un*interest.

If the creation of self-contained epistemologies allowed both scientists and the public to explore their own visions of the natural world, one question remains: Why did workers who neither reaped the social rewards of science nor experienced interest in their work continue to work at observatories? Long hours at a tedious job and substandard remuneration were the requirements of these jobs. While some employees might have been drawn to the odd hours and lack of responsibility, many workers held professional degrees and yet did little more than mark checks in a box. Why settle for underemployment?

Practical considerations aside, it might be suggested (and only suggested) that workers of the nineteenth century found creative and interesting ways to transcend boredom by elevating their tasks to ritual-like behaviour.[97] Though phrases like 'bored to death' and 'bored stiff' suggest no way out from the long and tiresome hours, observers and computers had other outlets for their feelings. Absent the defence of irony (practiced in full force by the bored observers and computers of today) nineteenth-century astronomical workers might have transcended their boredom through that other great feature of modern scientific life: suffering. Instead of the long hours as tedium, the long hours became trials of endurance. Not necessarily sacrificial in the religious sense,[98] workers may have found contexts in which their labours worked for a greater good; not facing back to the martyr but forward to the professional man. Boredom and quiet suffering were simultaneously causes and expressions of an entirely new form of work.

The literature of the period records several instances of activity that could be considered as either producing boredom or suffering, depending upon the outlook of the historical actor. For Ball, who spoke of the 'sacrifice' he and his employees made, the late nights at the Naval Observatory were a form of necessary suffering, but for observatory directors like Airy, the activity of observatory employees seemed simply tiresome.[799] Boredom and suffering were linked, which the observer alternatively experienced like a gestalt switch depending upon the context. As the most brilliant literary expositor of boredom wrote:

> The pendulum oscillates between these two terms: Suffering—that opens a window on the real… and Boredom…that must be considered as the most tolerable because the most durable of human evils. [100]

If Beckett was right, and boredom and suffering were indeed endpoints on a continuum of modern existence, it may be that observatory employees anticipated twentieth-century service work rather than replicated nineteenth-century factory workers and clerks; more Willie Loman than Bartleby.

More than coal miners and accountants, whose work was rarely connected to anything larger than the direct product of their labour, observatory workers had the dichotomous experience of a boring experience and an ostensibly grand *raison d'être*, pioneers for some forms of contemporary employment. Much scientific knowledge, at least as it concerned positional astronomy in the nineteenth century, occurred through the ability of observers to effect a transformation of one feeling into the other. In doing so they may have helped elevate their status to what Weber would later label a 'calling.'[101] By taking what by any measure was a hard and tedious activity and masking it in a greater purpose, workers may have found their own justifications.[102] If indeed these workers did subsume their feelings of boredom within a self-manufactured sense of meaning, they would not have been the last employees, in science or elsewhere, to have done so.

The new relation between the public and a distant science is seen in the organization of the great nineteenth-century compendium of astronomical literature: Jean-Claude Houzeau's *Vade-Mecum*. In a bibliography of the most important works published in Europe, Houzeau offered four categories of literature, each with a different audience and function: *Rudiments,* popular introductions for beginners; *Éléments,* explanations of material techniques for advanced students and potential future observatory employees or amateurs; *Traités*, for the mathematical and theoretical foundations of observational practice, and *Grandes ouvrages didactiques*, which attempted to summarize all the theory and practice of astronomy combined with a history of the discipline.[103] In all, Houzeau found 203 works since the late eighteenth century, nearly half of which (96) were *éléments* devoted to the practice of professional work. Houzeau also included a list of poetic works which dealt with astronomy from antiquity and the early modern period, yet nothing from the nineteenth century. Though popular works included such novel ideas as *Astronomie pour les dames* and other *vulgarisations* for non-professionals, Houzeau's classification demonstrated that astronomy could no longer be best explained through *belles-lettres* or the arts. For the intended audience of the *eléments, traités,* and *grande ouvrages*, the science of astronomy was intimately tied to rigorous practice.

1 G. B. Airy, *Gravitation: An Elementary Explination of the Principal Perterbations in the Solar System*, 2nd edn, London, 1884.
2 F. Arago, *Astronomie Populaire*, 4 vols., Vol. 1, Paris, 1854.
3 W. J. Ashworth. 'The Calculating Eye: Baily, Herschel, Babbage and the Business of Astronomy', *The British Journal for the History of Science* (1994), 27, 409-41.
4 *An Astronomical Ephemeris, Calendar, or Almanack for the Year of Our Lord 1783*, Hartford, 1783.
5 D. Aubin. 'Observatory Mathematics in the Nineteenth Century', in *The Oxford Handbook of the History of Mathematics* (ed. Eleanor Robson and Jackie Stedall), Oxford, 2009.
6 C. Babbage, *Reflections on the Decline of Science in England, and on Some of Its Causes*, New York, 1970.
7 W. V. Ball, ed. *Reminiscences and Letters of Sir Robert Ball*, London, 1915.
8 S. Beckett, *Proust*, New York, 1970.
9 J. B. Biot, *Traité Élémentaire D'astronomie Physique*, 2nd edn, Paris, 1810.
10 B. B.-V. a. C. Blondel, ed. *Science and Spectacle in the European Enlightenment*, Burlington VT., 2008.
11 G.-L. L. Buffon, *A Natural History*, New Edition edn, Vol. 1, Boston, 1831.

12 J. Cannales. 'Photogenic Venus: The "Cinematographic Turn" And Its Alternatives in Nineteenth-Century France', *ISIS* (2002), 93, 585-613.
13 S. F. Cannon, *Science in Culture: The Early Victorian Period*, New York, 1978.
14 G. F. Chambers, *A Handbook of Descriptive Astronomy*, 3rd edn, Oxford, 1877.
15 A. Chapman, *The Victorian Amateur Astronomer: Independent Astronomical Research in Britain, 1820-1920*, Chichester, 1998.
16 J. R. Christianson, *On Tycho's Island: Tycho Brahe and His Assistants, 1570-1601*, Cambridge, 2000.
17 A. M. Clerke. 'Astronomy Still Young', in *The Book of the Cosmos: Imagining the Universe from Heraclitus to Hawking*, Cambridge, Mass., 2000, 326-33.
18 R. Collins, *The Sociology of Philosophies: A Global Theory of Intellectual Change*, Cambridge, Mass, 1998.
19 Andreas W. Daum. 'Varieties of Popular Science and the Transformations of Public Knowledge: Some Historical Reflections', *Isis* (2009), 100, 319-32.
20 R. L. Duncombe. 'Personal Equation in Astronomy', *Popular Astronomy* (1945), 53, 2-12, 63-76, 110-21.
21 J. Evans, *The History and Practice of Ancient Astronomy*, Oxford, 1998.
22 A. Ewing, *Practical Astronomy: Containing a Description of the Solar System; the Doctrine of the Sphere; the Principal Problem in Astronomy*, Edinburgh, 1797.
23 F.R.S., *Thoughts on the Degradation of Science in England*, London, 1847.
24 L. M. d. Fontanes. 'Essai Sur L'astronomie', in *Oeuvres De M. De Fontanes*, Paris, 1839.
25 L. B. Francoeur, *Astronomie Pratique: Usage Et Composition De La Connaisance Des Temps*, Paris, 1840.
26 P. Galison, *How Experiments End*, Chicago, 1987.
27 U. Geuter, *The Professionalization of Psychology in Nazi Germany*, Cambridge, 1992.
28 C. C. Gillispie, *Science and Polity in France: The End of the Old Regime*, Princeton, NJ, 1980.
29 ———, *Science and Polity in France: The Revolutionary Years*, Vol. II, Princeton, NJ, 2004.
30 E. S. Goodstein, *Experience without Qualities: Boredom and Modernity*, Palo Alto, 2005.
31 Gould, *Reduction of the Observations of Fixed Stars Made by Joseph Lepaute D'agelet, at Paris, 1783-1785*, Washington, D.C., 1866.
32 I. Hacking, *The Taming of Chance*, Cambridge, 1990.
33 S. D. Healy, *Boredom, Self, and Culture*, Rutherford, 1984.
34 D. B. Herrmann. 'An Exponential Law for the Establishment of Observatories in the Nineteenth Century', *Journal for the History of Astronomy* (1973), 4, 57-8.
35 ———, *The History of Astronomy from Herschel to Hertzsprung*, Cambridge, 1973.
36 J. Herschel. 'Preface', in *A Catalogue of 9766 Star in the Southern Hemisphere*, London, 1847.
37 R. Herzig, *Suffering for Science: Reason and Sacrifice in Modern America*, New Brunswick, N.J., 2005.
38 P. G. a. B. Hevly, ed. *Big Science: The Growth of Large-Scale Research*, Stanford, Cal., 1992.
39 M. A. Hoskin, ed. *The General History of Astronomy*, 4 vols., Cambridge, 1984.
40 J.-C. Houzeau, *My Passage at the New Orleans Tribune : A Memoir of the Civil War Era*, Baton Rouge, La., 1984.
41 R. Hutchins, *British University Observatories*, Burlington, Vt., 2008.
42 J. T. Kelly, *Practical Astronomy During the Seventeenth Century: Almanac-Makers in America and England*, New York, 1991.
43 T. W. Kneeland. 'Managing Science and Technology: A Study of Change, 1868-1919', in *History of Science*, Norman, 1993.

44 T. Kuhn, *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought* Cambridge, Mass., 1957.
45 ———, *The Structure of Scientific Revolutions*, Chicago, 1962.
46 J. C. H. a. A. Lancaster, ed. *Bibliographie Général De L'astronomie*, Brussels, 1889.
47 B. Latour, *Laboratory Life: The Social Construction of Scientific Facts*, Beverly Hills, Calif., 1979.
48 O. M. Mitchel, *The Planetary and Stellar Worlds: A Popular Exposition of the Great Discoveries and Theories of Modern Astronomy*, New York, 1848.
49 E. J. C. Morton, *Heroes of Science: Astronomers*, London, 1882.
50 S. Newcomb, *Reminiscences of an Astronomer*, Boston, 1903.
51 R. O'Connor. 'Reflections on Popular Science in Britain: Genres, Categories, and Historians', *Isis* (2009), 100, 333-45.
52 K. Pandora. 'Popular Science in National and Transnational Perspective: Suggestions from the American Context', *Isis* (2009), 100, 346-58.
53 B. Pascal, *Pensées*, Indianapolis, Ind., 2005.
54 C. o. S. E. a. P. Policy, *On Being a Scientist: Responsible Conduct in Research*, 2nd edn, Washington, D.C., 1995.
55 T. M. Porter. 'How Science Became Technical', *Isis* (2009), 100, 292-309.
56 R. A. Proctor, *Old and New Astronomy*, London, 1888.
57 'Public Praises Science; Scientists Fault Public, Media'. 2009.
58 A. Quetelet, *Astronomie Populaire*, 2nd edn, Brussels, 1832.
59 ———. 'Extrait D'un Rapport Sur La Formation D'un Observatoire Dans Le Royaume Des Pays-Bas', *Correspondance Mathématique et Physique* (1825), 1, 67-70.
60 W. Raleigh, *Style*, London, 1897.
61 R. T. R. Robinson, *Places of 5,345 Stars: Observed from 1828 to 1854 at the Armagh Observatory*, Dublin, 1859.
62 S. Schaffer. 'Astronomers Mark Time: Discipline and the Personal Equation', *Science in Context* (1988), 2, 115-45.
63 A. Schopenhauer, *The World as Will and Representation*, 2 vols., Vol. 1, New York, 1969.
64 R. Sheepshanks, *A Letter to the Visitors of the Greenwich Royal Observatory in Reply to the Calumnies of Mr. Babbage...* London, 1860.
65 R. W. Smith. 'A National Observatory Transformed: Greenwich in the Nineteenth Century', *Journal of the History of Astronomy* (1991), 22, 5-21.
66 ———. 'Remaking Astronomy: Instruments and Practice in the Nineteenth and Twentieth Centuries', in *The Modern Physical and Mathematical Science* (ed. Mary Jo Nye), Cambridge, 2002.
67 E. S. H. Smithsonian Institution, George Hans Boehmer. 'Reports of Astronomical Observatories for 1880', Washington, D.C., 1881.
68 M. L. H. Susan R. Singer, and Heidi A. Schweingruber, *America's Lab Report: Investigations in High School Science*, Washington, D.C., 2005.
69 J. M. a. A. Thackery, *Gentleman of Science: Early Years of the British Association for the Advancement of the Sciences*, Oxford and New York, 1981.
70 J. R. Topham. 'Introduction', *Isis* (2009), 100, 310-8.
71 J. Tranter. 'Biology: Dull, Lifeless, and Boring?', *Journal of Biological Education* (2004), 38, 104-5.
72 M. Weber, *The Vocation Letters*, Indianapolis, 2004.

73 J. A. Westwood, ed. *Astronomy for Amateurs: A Practical Manual of Telescope Research in All Latitudes*, London, 1888.
74 R. Woodhouse, *An Elementary Treatise on Astronomy*, Cambridge, 1812.

1 Walter Raleigh, *Style* (London: Edward Arnold, 1897), 59.

2 *The Simpsons,* episode 2F11, original airdate Feb. 3, 1995.

3 On the difficulty of engaging students see *A Nation at Risk* and Margaret L. Hilton Susan R. Singer, and Heidi A. Schweingruber, *America's Lab Report: Investigations in High School Science* (Washington, D.C.: The National Academies Press, 2005), xii. On general boredom in the classroom, see John Tranter, "Biology: Dull, Lifeless, and Boring?," *Journal of Biological Education* 38, no. 3 (2004).

4 "Public Praises Science; Scientists Fault Public, Media," (Pew Research Center, 2009).

5 In the same episode, Bart’s participation in the scientific enterprise is even seen as punishment. The task was imposed because Bart had foiled Skinner’s earlier attempt to float a weather balloon: ‘Because you have impeded science, you must now *aid* science.’

6 This is not to confuse boredom with the merely mundane. Latour and Gallison have argued persuasively for the role quotidian practice in resolving scientific problems. Peter Galison, *How Experiments End* (Chicago: Chicago University Press, 1987). Bruno Latour, *Laboratory Life: The Social Construction of Scientific Facts* (Beverly Hills, Calif.: Sage Publications, 1979). Such works builds on Kuhn’s understanding of ‘normal science.’ Thomas Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1962).

7 Most recently in the ‘Focus’discussion of ISIS. Andreas W. Daum, "Varieties of Popular Science and the Transformations of Public Knowledge: Some Historical Reflections," *Isis* 100, no. 2 (2009), Ralph O'Connor, "Reflections on Popular Science in Britain: Genres, Categories, and Historians," *Isis* 100, no. 2 (2009), Katherine Pandora, "Popular Science in National and Transnational Perspective: Suggestions from the American Context," *Isis* 100, no. 2 (2009), Jonathan R. Topham, "Introduction,"

Isis 100, no. 2 (2009).

8 Porter has recently examined this phenomenon in Theodore M. Porter, "How Science Became Technical," *Isis* 100 (2009). This work is in a sense a companion piece, examining the other side of the 'technical.'

9 Rebecca Herzig, *Suffering for Science: Reason and Sacrifice in Modern America* (New Brunswick, N.J.: Rutgers University Press, 2005). Latour, *Laboratory Life: The Social Construction of Scientific Facts*.

10 Nineteenth-century commentators had many names for these activities, including *positional, computational, observational* or *pure* astronomy, but all referred to the practice of creating accurate ephemerides and star catalogs rather than theoretical investigation of celestial movement.

11 James Evans, *The History and Practice of Ancient Astronomy* (Oxford: Oxford University Press, 1998).

12 The following discussion will focus primarily on observatories in England, France, and America.

13 On the use of the term 'deskilling' in connection to astronomy workers, see David Aubin, "Observatory Mathematics in the Nineteenth Century," in *The Oxford Handbook of the History of Mathematics*, ed. Eleanor Robson and Jackie Stedall (Oxford: Oxford, 2009).

14 While the literature of professionalization is large, a representative sample would include for England, Jack Morrell and Arnold Thackery, *Gentleman of Science: Early Years of the British Association for the Advancement of the Sciences* (Oxford and New York: Oxford University Press, 1981). For France, the model continues to be Charles Coulton Gillispie, *Science and Polity in France: The End of the Old Regime* (Princeton, NJ: Princeton University Press, 1980), Charles Coulton Gillispie, *Science and Polity in France: The Revolutionary Years*, vol. II (Princeton, NJ: Princeton

University Press, 2004). For Germany, an excellent summary of the literature can be found in Ulfred Geuter, *The Professionalization of Psychology in Nazi Germany*, trans. Richard J. Holmes (Cambridge: Cambridge University Press, 1992), 20-32.

15 J.C. Houzeau and A. Lancaster, ed., *Bibliographie Général De L'astronomie* (Brussels: Hayez, 1889), 1.

16 Ibid.

17 The most comprehensive account of the integration of astronomical and intellectual history is Michael A. Hoskin, ed., *The General History of Astronomy*, 4 vols. (Cambridge: Cambridge University Press, 1984). Foundational works of the genre include Thomas Kuhn, *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought* (Cambridge, Mass.: Harvard University Press, 1957). (MORE)

18 On the relationship of astronomy to accounting, see William J. Ashworth, "The Calculating Eye: Baily, Herschel, Babbage and the Business of Astronomy," *The British Journal for the History of Science* 27, no. 4 (1994).

19 John T. Kelly, *Practical Astronomy During the Seventeenth Century: Almanac-Makers in America and England* (New York: Garland, 1991), 13.

20 *An Astronomical Ephemeris, Calendar, or Almanack for the Year of Our Lord 1783*, (Hartford: Hudson and Goodwin, 1783).

21 Louis Marquis de Fontanes, "Essai Sur L'astronomie," in *Oeuvres De M. De Fontanes* (Paris: Hachette, 1839).

22 Exceptions do exist. It has been argued that Brahe's Island of Urania provided a similar form of 'big science' much earlier. John Robert Christianson, *On Tycho's Island: Tycho Brahe and His Assistants, 1570-1601* (Cambridge: Cambridge University Press, 2000). Yet Tycho's utopia of natural philosophy stands out in the history of scientific organization prior to the nineteenth century.

23Charles Babbage, *Reflections on the Decline of Science in England, and on Some of Its Causes* (New York: Kelly, 1970), 152.

24 Ibid., 11.

25 Ibid., 166.

26 Ibid., xii.

27 F.R.S., *Thoughts on the Degradation of Science in England* (London: Rodwell, 1847), 7.

28 Ashworth, "The Calculating Eye: Baily, Herschel, Babbage and the Business of Astronomy.", Aubin, "Observatory Mathematics in the Nineteenth Century.", Susan Faye Cannon, *Science in Culture: The Early Victorian Period* (New York: Science History Publications, 1978).

29 Robert W. Smith, "Remaking Astronomy: Instruments and Practice in the Nineteenth and Twentieth Centuries," in *The Modern Physical and Mathematical Science*, ed. Mary Jo Nye (Cambridge: Cambridge University Press, 2002), 154.

30 Simon Newcomb, *Reminiscences of an Astronomer* (Boston: Houghton Mifflin, 1903), 273.

31 Timothy William Kneeland, "Managing Science and Technology: A Study of Change, 1868-1919" (Oklahoma University, 1993), Simon Schaffer, "Astronomers Mark Time: Discipline and the Personal Equation," *Science in Context* 2, no. 1 (1988), Robert W. Smith, "A National Observatory Transformed: Greenwich in the Nineteenth Century," *Journal of the History of Astronomy* 22, no. 1 (1991).

32 Seán Desmond Healy, *Boredom, Self, and Culture* (Rutherford: Farleigh Dickinson Press, 1984), 27.

33 Blaise Pascal, *Pensées*, trans. Roger Ariew (Indianapolis, Ind.: Hackett Publishing, 2005), 24, 163.

34 Elizabeth S. Goodstein, *Experience without Qualities: Boredom and Modernity* (Palo Alto: Stanford, 2005), Healy, *Boredom, Self, and Culture*.

35 Healy, *Boredom, Self, and Culture*, 10.

36 Adolphe Quetelet, *Astronomie Populaire*, 2nd ed. (Brussels: Remy, 1832), vi.

37 John A. Westwood, ed., *Astronomy for Amateurs: A Practical Manual of Telescope Research in All Latitudes* (London: Longman's, Green, and Co., 1888).

38 Dieter B. Herrmann, "An Exponential Law for the Establishment of Observatories in the Nineteenth Century," *Journal for the History of Astronomy* 4 (1973): 57.

39 Roger Hutchins, *British University Observatories* (Burlington, Vt.: Ashgate, 2008), 13-51.

40 State of the Union Address, Dec. 6, 1825. (http://www.presidency.ucsb.edu/ws/index.php?pid=29467)

41 Adolphe Quetelet, "Extrait D'un Rapport Sur La Formation D'un Observatoire Dans Le Royaume Des Pays-Bas," *Correspondance Mathématique et Physique* 1 (1825).

42 A possible exception was France, where the flagship Paris Observatory suffered from a lack of sustained leadership. Aubin, "Observatory Mathematics in the Nineteenth Century."

43 San Francisco Chronicle, 1897, Oct. 20

44 Richard Sheepshanks, *A Letter to the Visitors of the Greenwich Royal Observatory in Reply to the Calumnies of Mr. Babbage...* (London: Barclay, 1860), 5.

45 Rev. T.R. Robinson, *Places of 5,345 Stars: Observed from 1828 to 1854 at the Armagh Observatory* (Dublin: Thom & Sons, 1859), v.

46 Edward Singleton Holden Smithsonian Institution, George Hans Boehmer, "Reports of Astronomical Observatories for 1880," (Washington, D.C.: Smithsonian, 1881).

47 Ian Hacking, *The Taming of Chance* (Cambridge: Cambridge University Press, 1990).

48 Raynor L. Duncombe, "Personal Equation in Astronomy," *Popular Astronomy* 53, no. ` (1945): 3-9.

49 For the problems in 'individual difference' in observations of the transit of Venus in 1874, see Jimena Cannales, "Photogenic Venus: The "Cinematographic Turn" And Its Alternatives in Nineteenth-Century France," *ISIS* 93, no. 4 (2002).

50 Schaffer, "Astronomers Mark Time: Discipline and the Personal Equation."

51 Newcomb, *Reminiscences of an Astronomer*, 110.

52 Ibid., 111.

53 From a letter from Charles Biddell Airy to Charles Wood, 22 March 1847. Quoted on 34 of Allan Chapman, *The Victorian Amateur Astronomer: Independent Astronomical Research in Britain, 1820-1920* (Chichester: John Wiley & Sons, 1998).

54 Dieter B. Herrmann, *The History of Astronomy from Herschel to Hertzsprung*, trans. Kevin Krisciunas (Cambridge: Cambridge University Press, 1973), 158.

55 *The Observatory,* 1895, V. 18, p.175.

56 L. B. Francoeur, *Astronomie Pratique: Usage Et Composition De La Connaisance Des Temps* (Paris: Bachelier, 1840), vii.

57 The Observatory, 1895, 377

58 Gould, *Reduction of the Observations of Fixed Stars Made by Joseph Lepaute D'agelet, at Paris, 1783-1785* (Washington, D.C.: National Academy of Sciences, 1866), 70.

59 George Biddell Airy, *Gravitation: An Elementary Explination of the Principal Perterbations in the Solar System*, 2nd ed. (London: MacMillan, 1884), 123.

60 Aubin, "Observatory Mathematics in the Nineteenth Century," 283.

61 John Herschel, "Preface," in *A Catalogue of 9766 Star in the Southern Hemisphere* (London: Taylor, 1847).

62 Ibid.

63 *The Observatory,* Vol. 20 (1897), 115.

64 Newcomb, *Reminiscences of an Astronomer*, 62.

65 *The Observatory,* Vol. XVII (1895), 175.

66 *The Observatory,* Vol. XX (1897), 115

67 Alexander Ewing, *Practical Astronomy: Containing a Description of the Solar System; the Doctrine of the Sphere; the Principal Problem in Astronomy* (Edinburgh: Peter Hill, 1797), vi.

68 O.M. Mitchel, *The Planetary and Stellar Worlds: A Popular Exposition of the Great Discoveries and Theories of Modern Astronomy* (New York: Baker & Scribner, 1848), v.

69 Agnes Mary Clerke, "Astronomy Still Young," in *The Book of the Cosmos: Imagining the Universe from Heraclitus to Hawking* (Cambridge, Mass.: Perseus, 2000), 327.

70 Ewing, *Practical Astronomy: Containing a Description of the Solar System; the Doctrine of the Sphere; the Principal Problem in Astronomy*, v.

71 Ashworth, "The Calculating Eye: Baily, Herschel, Babbage and the Business of Astronomy."

72 Airy, *Gravitation: An Elementary Explination of the Principal Perterbations in the Solar System*, iv.

73 The Observatory, Vol. 18 (1895), 376

74 E.J.C Morton, *Heroes of Science: Astronomers* (London: Society for Producing Christian Knowledge, 1882), v.

75 George F. Chambers, *A Handbook of Descriptive Astronomy*, 3rd ed. (Oxford: Clarendon Press, 1877), vii.

76 Ibid.

77 François Arago, *Astronomie Populaire*, 4 vols., vol. 1 (Paris: Claye, 1854), iii.

78 Ibid., iv.

79 Ibid., xii.

80 *The Observatory*, XVIII (1895) 106

81 *The Observatory*, XIX (1896), 69

82 *The Observatory*, XVIII (1895), 377

83 Ibid, 177.

84 Peter Galison and Bruce Hevly, ed., *Big Science: The Growth of Large-Scale Research* (Stanford, Cal.: Stanford University Press, 1992).

85 Richard A. Proctor, *Old and New Astronomy* (London: Longman's, Green, and Co., 1888), iii.

86 Ibid., 4.

87 Ibid., 9.

88 The best example remains Schaffer, "Astronomers Mark Time: Discipline and the Personal Equation." See also Bernadette Bensaude-Vincent and Christine Blondel, ed., *Science and Spectacle in the European Enlightenment* (Burlington VT.: Ashgate, 2008).

89 Robert Woodhouse, *An Elementary Treatise on Astronomy* (Cambridge: Smith, 1812), viii.

90 Ibid.

91 Ibid., xiv.

92 Proctor, *Old and New Astronomy*.

93 Arago, *Astronomie Populaire*, i.

94 J.B. Biot, *Traité Élémentaire D'astronomie Physique*, 2nd ed. (Paris: Klostermann, 1810), ix.

95 Ibid., x.

96 Commitee on Science Engineering and Public Policy, *On Being a Scientist: Responsible Conduct in Research*, 2nd ed. (Washington, D.C.: National Academy Press, 1995).

97 The literature on ritual in laboratory and observational practice is immense, though most case studies have focused on twentieth-century science. Foundational works include Randall Collins, *The Sociology of Philosophies: A Global Theory of Intellectual Change* (Cambridge, Mass: Belknap Press, 1998), Latour, *Laboratory Life: The Social Construction of Scientific Facts*.

98 Such metaphors to religious practice efface what was most shocking about scientific life: its utter *newness*.

99 W. Valentine Ball, ed., *Reminiscences and Letters of Sir Robert Ball* (London: Cassell, 1915).

100 Samuel Beckett, *Proust* (New York: Grove Press, 1970), 16. He may have been referencing Schopenhauer, who wrote that 'life swings back and forth like a pendulum to and fro between pain and boredom.' Arthur Schopenhauer, *The World as Will and Representation*, trans. E.F.J. Payne, 2 vols., vol. 1 (New York: Dover Publications, 1969), 312.

101 'Science as a Vocation.' Max Weber, *The Vocation Letters*, trans. Rodney Livingstone (Indianapolis: Hackett, 2004).

102 Whether these meanings did or did not overlap with those of their employers would be an interesting subject for further historical investigation.

103 Jean-Charles Houzeau, *My Passage at the New Orleans Tribune : A Memoir of the Civil War Era*, trans. Gerard F. Denault (Baton Rouge, La.: Lousiana State Press, 1984), 2.