The scholarly self under threat: language of vice in British scholarship (1870-1910)

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Peter Guthrie Tait and the Victorian imagination

Introduction

In 1871, the Scottish energy physicist Peter Guthrie Tait accused the London-based scientific naturalist John Tyndall of thwarting the progress of science by attributing too great a role to the creative imagination: 'Are we to live, scientifically, in the same way as alchemists and astrologers did in the Middle Ages? And are we to ignore all that Bacon and Newton have done for us? . . . Let us use the imaginative faculty by all means; but in doing so, let us take our stand on the firm ground of the known before we venture ourselves into the unknown.'[1]

In this attack on Tyndall's use of the imagination, Tait was reacting to Tyndall's 1870 lecture 'On the Scientific Use of the Imagination', in which the latter presented science as revolving around the creative faculty of scientific men.[2] Tyndall thought that some problems in science, especially those relating to the exact make-up of matter, the scope of evolution, and the origin of matter and energy, could only be resolved with an appeal to the faculty of the imagination. In order for the creative imagination to be effective, men of science should employ virtues of 'courage', 'manful willingness', and 'tolerance' for those who could make these great 'leaps of

1 Tait, 'Imagination in Science', *Nature* 3 (72), 395.
2 John Tyndall, 'On the Scientific Use of the Imagination', in: John Tyndall, *Essays on the Use and Limit of the Imagination in Science* (London: Longmans, Green, &Co., 1870) 13-51. Note that both Tait and Tyndall referred to themselves as 'men of science'.

imagination'.[3] For Tyndall, the imagination was one of the most important tools in the Victorian scientific toolbox and should be given a free rein. Products of the imagination should only *subsequently* be checked by the faculty of reason.[4] The imagination, in other words, held primacy in scientific methodology. Therefore, men of science were to practice virtues that enabled the imagination to flourish.

Tait, however, associated such a free rein for the imagination with the Middle Ages and claimed that the revolutionary work of Newton and Bacon had been undone by Tyndall, whose view of science reminded him of the occult and backward pursuits of alchemists and astrologers. Tait clearly held a different view of the imagination in science to that of Tyndall. Where Tyndall advocated freedom, tolerance, courage and willingness, Tait called for restraint and caution, and appealed to the successes of scientific methodology as exemplified by Francis Bacon (1561-1626) and Isaac Newton (1643-1727).[5]

The clash between Tyndall and Tait over the imagination, the ideal character of scientific men and the relation of these two to the progress of science was one of many: throughout the 1860s and 1870s, Tait and Tyndall frequently exchanged unpleasant words in print and in many of those exchanges, they accused each other of vices. Tyndall's lack of restraint in using the imagination, Tait felt, was clearly an example of vicious behaviour, whereas Tyndall accused Tait of being overly cautious and conservative. Beside Tyndall, the Scotsman Peter Guthrie Tait clashed with others too. In fact, Tait pitted himself against creative metaphysicians such as Clement Mansfield Ingleby and Herbert Spencer as well, who, in Tait's eyes, failed to discipline their intuitions and imaginations with virtues of restraint, caution, accuracy and patience.

3 Tyndall, 'On the Scientific Use of the Imagination', 44, 40.
4 Ibid. 45.
5 I have discussed the clash between Tait and Tyndall in more detail in Saarloos, 'Virtues of Courage and Virtues of Restraint'.

The previous two chapters have told a story of consensus. Victorian and Edwardian scholars generally agreed that to pursue knowledge was to walk a narrow path of virtue and to keep vices at bay at all costs. This chapter will deal with controversy and disagreement. The above example of Tait versus Tyndall shows that a consensus about the moral nature of scholarship indeed existed (why else would they both use the language of virtue and vice), but, more importantly, it also shows how deeply scholars disagreed about the goals and methods of scholarship, and the ideal character of te scholar. This deep disagreement gave rise to vice charges. If all indeed agreed that vices threatened the scholarly self, then vices had to be actively identified and neutralised. Not only in oneself, but in others too. This disagreement, I will argue, is the second reason for the importance of the category of vice in Victorian and Edwardian scholarship.

Therefore, this chapter will focus specifically on the language of vice that was employed in Victorian debates over the role of the imagination in science. Interestingly, central to these debates on the imagination was not the faculty of the imagination in itself. In fact, all parties agreed that a certain degree of creativity or imagination was needed in science. What they did not agree on, however, were the epistemic virtues needed to safely and productively guide these human faculties to good scientific knowledge, because there was no consensus about what good science was in the first place. What was a virtue to one party could be a vice to the other. Peter Guthrie Tait's quarrels with others on this subject offer an intriguing insight, not in the least because Tait was both a respected mathematical physicist and a feared polemicist. Unlike other Victorian physicists –Maxwell, Tyndall, Thomson–, Tait has not received much attention in the form of biographies, so an account of his controversies and conceptions of science might also add a new perspective on other debates on Victorian physics.[6]

Let me briefly state the premise and aim of this chapter. Central to this third chapter will be the faculty of the imagination, the catalogues

6 I discuss the historiography on Peter Guthrie Tait in a later section.

of virtues that scholars prescribed in dealing with this creative faculty, and the vice charges that were employed in debates over the imagination. I will approach these questions through a detailed study of four controversies of Peter Guthrie Tait with other eminent Victorians on this subject. This allows me to go beyond the broad description of ideals I have offered in the previous two chapters with a view to offering a more dynamic account of how these ideals were formulated and contested in scholarly debate.

I will analyse four major controversies around the imagination in which accusations of vice were uttered frequently. I shall begin by discussing the clash between Tait and Tyndall regarding the place held by James Prescott Joule (1818-1889) in the history of energy and the role of intuition and imagination in that history. Secondly, I will discuss the quarrel about Tyndall's lecture on the imagination in more detail, with a focus on the models of Newton and Faraday in this controversy. Thirdly, I will elaborate on the discussion between Peter Guthrie Tait and Clement Ingleby pertaining to the relative merits of metaphysics and mathematics; a discussion in which images of Newton and Leibniz also play a major role. And finally, this chapter will engage the vicious conflict between Peter Guthrie Tait and Herbert Spencer over *a priori* reasoning and the importance of observation versus the role of intuition and hypothesis in science. In all these quarrels, Tait was engaged in a negotiation of the Newtonian model of scientific selfhood, and was performing boundary work to protect *his* version of this model. Let me start, therefore, by discussing a few important historiographical themes that play a major role in my analysis of Tait's controversies: the imagination, genius and method, and personae. Thereafter, I will discuss Tait's own scientific ideals, before analysing how he pitted these against the views of his opponents.

Imagination

In the first chapter of this dissertation, I already discussed how academic memory culture defined the danger of enthusiasm, which was closely related to the use of imagination. Some points bear repeating, because they lend context to Tait's controversies. I have argued that enthusiastically following one's imagination was often felt to be at odds with ideals of communicability and objectivity: individual epistemic pursuits were not easily reconciled with collective standards and shared methods. The cases of Charles Wheatstone and Charles Smart Roy illustrate this: both Wheatstone and Roy were remembered for letting their enthusiasm in following their ingenuity interfere with the shared goals of the scientific community.[7] Moreover, when scholars relied too much on their imagination, this was repeatedly attributed to an inappropriate desire for fame or recognition.[8] In order for the imagination not to result in vice, it should be balanced by personal virtues such as accuracy, thoroughness and restraint. On the other hand, precisely these virtues of thoroughness and restraint might be seen as vices if they were practiced in excess: scholars such as Lord Acton and Thomas Graham erred too far in the other direction by cherishing thoroughness and completeness over productivity and creativity. The imagination, then, was a faculty that stood at the centre of multiple discussions about what a good scholar should be.

Tait's conflicts with other men of science about the imagination tie in neatly with a theme in historiography that I did not touch upon in earlier chapters: the opposition of genius and method in British science. Was science a collective project with shared methodologies and standards of quality, or was scientific progress the result of extraordinary contributions by unique individuals? Was science, in other words, a question of method, or genius? The answers to these questions had ramifications for the ideal character of the scholar as well: were virtues such as objectivity, impartiality, accuracy and perseverance the marks of a true 'man of science', or were creativity, courage and open-mindedness more important? Tait would unambiguously choose the first answer, while Tyndall would opt for the second.

7 See the section on 'Enthusiasm' in chapter 1.

8 The case of George John Romanes, who was accused of self-seeking when he sought to offer an innovative alternative to Charles Darwin's doctrine of evolution is a good example. See the section on 'Fame' in chapter 1.

In general, historians of science have described the tension between genius and method in the late nineteenth century in terms of a conflict between imaginative subjectivity and methodological objectivity. Lorraine Daston, for example, has argued that the 'soaring imagination' of geniuses was increasingly seen as problematic and excessively artistic, because it threatened the standard of communicability.[9] As the nineteenth century progressed, the imagination became more and more associated with the *persona* of the artist, and dissociated from that of the scientist.[10] Nonetheless, as the imagination did remain a potent force in scientific discovery, it could not be neglected, but should instead be disciplined by virtues of restraint, caution, and patience, virtues more commonly associated with scientific method. A union of both genius and method was needed, in which the imagination was balanced by other personal traits. The exact make-up of this union was not agreed upon, as the controversies of Tait will illustrate.

In the debates on whether imaginative genius or dutiful method was more important, the Victorians drew heavily on their own scientific past. More specifically, as was already showcased in the quote with which this chapter began, Isaac Newton and Francis Bacon made a comeback in the nineteenth century as models for what it took to be a good scholar. In biographical texts, the images of Newton and Bacon were appropriated for several scientific causes and differing outlooks on the question of genius and method. Early and mid-century biographers such as David Brewster (1781-1868) and Augustus De Morgan (1806-1871) each presented a

9 I have argued in chapter 1 that communicability was not only threatened by the imagination, but by uselessness and distraction as well. Daston, 'Fear and Loathing', 81.

10 Ibid. 86-89.

different image of Newton and Bacon to suit their own agendas.[11] 'Newton' and 'Bacon' came to signify much more than scientific heroes of the past; they became models of scientific selfhood, shorthand for a specific way of doing science and being a scientific man. Such shorthands are often referred to as personae in historiography.[12]

Although there was no tangible or precise consensus about what 'Newton' or 'Bacon' stood for, the fact that these models of scholarly selfhood were linked to images of real, historical figures delineated the range of options for interpretation. 'Newton' stood for a combination of imaginative genius and inductive virtues of patience, caution and impartiality, although the exact balance of these attributed qualities varied per representation. 'Bacon', on the other hand, was associated with the inductive method and a rigid disciplining of genius and imagination, but was no longer unanimously regarded positively in nineteenth-century Britain.[13] Tait's invocation of Newton and Bacon in his critique on Tyndall, therefore, should be seen in the larger context of these discussions of the vices of genius and the virtues of method. Other images and models circulated as well: think of the experimental Faraday, or the continental and metaphysical Hegel or

11 Richard Yeo has shown how Newton's biographers all positioned Newton somewhere on the spectrum between genius and method, and how and why the notion of genius became distrusted as the nineteenth century progressed, while Rebekah Higgitt has elaborated on the intersection between Newtonian biography and new standards of history writing in nineteenth-century Britain. Richard Yeo, 'Genius, Method and Morality'; Higgitt, *Recreating Newton*. For other work on Newton's image, genius and biographies, see: Fara, *Newton: The Making of Genius*; and: Paul Theerman, 'Unaccustomed Role: The Scientist as Historical Biographer – Two Nineteenth-Century Portrayals of Newton', *Biography* 8 (1985) 145-162.

12 For personae as models of scientific selfhood, see: Daston and Sibum, 'Introduction: Scientific Personae and Their Histories'; Herman Paul, 'What is a scholarly persona?'; Gadi Algazi, 'At the Study: Notes on the Production of the Scholarly Self', in: David Warren Sabean and Malina Stefanovska (eds.), *Space and Self in Early Modern European Cultures* (Toronto: University of Toronto Press, 2012) 17-5; and the entire 4th issue of the 131th volume of the BMGN on personae, but especially Gadi Algazi's contribution, in which the concept is explained on three different levels: Algazi, 'Exemplum and Wundertier'.

13 Yeo, 'An Idol of the Marketplace'.

Goethe.[14]

One of the historiographical insights that is quite relevant for my purposes here is the observation that these models were often, as in the case of 'Newton' or 'Bacon', linked to specific names of scientists or scholars. Herman Paul, for example, discussing German historical scholarship, has shown that names of historians such as 'Waitz', 'Janssen' or 'Ranke' stood for a specific way of being a historian, and, as such, were coordinates on an imaginary map of the historical discipline.[15] Again, for some the label of 'Waitz' or 'Ranke' was a sign of virtue, while for others, this was seen as a vicious way of being a historian. Paul also draws attention to the polemical context of these models: 'scholarly personae did not integrate the field; they represented points of contention'.[16] When Tait mentioned Bacon and Newton in his review of Tyndall, we should, therefore, not overlook this: 'Bacon' and 'Newton' were also coordinates on a map of Victorian science, and like the models Paul writes about, 'Bacon' and 'Newton' also represented points of contention and disagreement.

Before I will turn to Tait's controversies and the language of vice in them, I will introduce Tait himself. This introduction is twofold: I will turn to Tait himself and his image of Newton first, and discuss his position in historiography afterwards.

Peter Guthrie Tait and the image of Newton

Peter Guthrie Tait was born to John and Mary Tait on the 28th of April 1831 in Dalkeith, a small village just south of Edinburgh. When Peter Tait was six years old, his father died, and his mother took him and his two sisters to live with her brother in Edinburgh. If we are to believe Tait's biographer and former student Cargill Gilston Knott (1856-1922), Tait was privately

14 Geoffrey Cantor, 'The scientist as hero: public images of Faraday'.
15 Paul, 'The Virtues of a Good Historian in Early Imperial Germany', 700-701.
16 Ibid. 705.

educated in science by his uncle John.[17] After this informal education, a solid basis for Tait's mathematical acumen was laid at Edinburgh Academy, where he learned basic mathematics in the classroom of James Gloag, 'a teacher of strenuous character and quaint originality', who instilled in Tait the conviction that 'mathematics was a mental and moral discipline'.[18] Already very early in his life, Tait learned that the disciplining of character was a necessary part of a proper scientific education.

Owing to the fact that they were both under Gloag's guidance, Tait also met his lifelong friend James Clerk Maxwell (1831-1879) at the Edinburgh Academy. Both performed very well at the Academy and went on to study at the University of Edinburgh, where they came under the influence of the physicist and glaciologist James David Forbes (1809-1868) and the mathematician Philip Kelland (1808-1879). Tait, however, left Edinburgh after one session to compete in the mathematical Tripos at Cambridge University, from which he emerged victoriously both as Senior Wrangler and winner of the Smith's prize for original mathematical research in 1851.[19] After his graduation, Tait took up a fellowship at Peterhouse College and soon established himself as a coach for aspiring Wranglers. Although he always felt the job of a coach to be rather tedious and unchallenging –at one point he even remarked that he could coach 'a coal scuttle to be Senior Wrangler'[20]–, he did use his time at Cambridge to

17 Cargill Gilston Knott, *Life and Scientific Work of Peter Guthrie Tait* (Cambridge: Cambridge University Press, 1911) 3. Knott compiled Tait's *Life* on the basis of Tait's own letters, reminisces by friends and former students, and the testimony of Margaret Tait.

18 Knott, *Life and Scientific Work*, 4.

19 Ibid. 9. Maxwell would follow Tait a few years later, on the latter's advice. The term 'Wrangler' refers to anyone that gained first-class honours in the Cambridge Mathematical Tripos. The 'Senior Wrangler' refers to the student that scored highest. For these terms and the 'making' of Wranglers through tutoring, see: Warwick, *Masters of Theory*, chapter 4 and 5.

20 Ibid. 11.

delve deeper in the study of mathematics.[21]

Tait's work in mathematics was crowned in 1854 by his appointment as Professor of Mathematics in Ireland, at Queen's College in Belfast. His move to Belfast was significant in two respects. First of all, Tait met Thomas Andrews (1813-1885), who was at that time Professor of Chemistry at Queen's College, and secondly, Tait started an extensive correspondence with the mathematician William Rowan Hamilton. Both men greatly influenced Tait's conception of science. Andrews acquainted him with experimental work and, according to Tait's biographer and mathematician George Chrystal, 'stimulated his love for well-directed physical research'.[22] Knott added that Andrews not only honed Tait's experimental skills, but that Tait also saw 'the extreme care and patience with which Andrews carried out all his researches' as a great example, and 'one of the most important determining factors' in his life.[23]

If Andrews was responsible for the development of Tait's skills and 'love' of experiment research, William Rowan Hamilton fulfilled this role for Tait's mathematical side. Hamilton, Professor of Astronomy at Trinity College in Dublin, was the illustrious originator of the mathematical concept of quaternions: an algebra to describe points in four-dimensional space. Quaternions were interesting to Hamilton because they transcended Cartesian systems of coordinates and provided a new way to describe points, and relations between these points in space. The composition of quaternions out of three numbers that formed the vector part and one number that functioned as the scalar part was of great influence to later theories of vector analysis, forwarded by Josiah Willard Gibbs (1839-1903) and Oliver

21 Tait would militate against the practice of cramming throughout his career, for example: Peter Guthrie Tait, 'Prof. Tait on "Cram"', *Nature* 9 (30 April 1874) 501-502.

22 G. Chrystal, 'Professor Tait', Nature 64 (25 July 1901) 305-307.

23 Knott, *Life and Scientific Work*, 13

Heaviside (1850-1925).[24] Tait himself grew interested in the quaternion method of analysis not because he was interested in purely mathematical theories of complex numbers, but because of 'the promise of usefulness in physical applications'.[25] Nonetheless, Tait became a 'zealous and competent disciple'[26] of Hamilton; they maintained an extensive correspondence until Hamilton's death in 1865, and Tait published extensively on the application of quaternions to physical science.[27]

In 1860, Tait left his professorship of mathematics at Belfast to return to the University of Edinburgh as Professor of Natural Philosophy. His former tutor Forbes had retired from the chair, and Tait was deemed a fitting replacement, although the competition for the chair had been fierce.[28] Despite the competition, Tait remained in Forbes' chair at the University of Edinburgh for more than forty years, until his failing health and the blow of the death of his son Freddie in the Anglo-Boer War forced him to retire in 1901. Tait saw lecturing as his primary duty, and primarily lectured on the general principles of science rather than on his own research.[29] Advanced students, however, would not be the passive recipient of Tait's general principles, but had to work actively in Tait's practical class, in which they were set to work on 'some real experimental problem'.[30] Tait's method of teaching was reminiscent of that of his own tutor, Gloag: he warned his students that the study of science was 'beset with difficulties', and he held

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24 For a lengthier discussion of the quaternion concept and its relation to vectorial systems, see: Michael J. Crowe, *History of Vector Analysis*: *The Evolution of the Idea of a Vectorial System* (Notre Dame, IN: University of Notre Dame Press, 1967).

25 Knott, *Life and Scientific Work*, 13.

26 Alexander Macfarlane, 'Peter Guthrie Tait', *Physical Review* 15 (1902) 51-64, 52.

27 Knott states that Tait worked on quaternions until the day he died, handing over his final notes to his son, with the instruction to handle them with care. Knott, *Life and Scientific Work*, 40.

28 Ibid. 17.

29 Macfarlane, 'Peter Guthrie Tait', 53.

30 Alexander Macfarlane, 'Peter Guthrie Tait, his life and works', *Bibliotheca Mathematica* 3rd series, 4 (1903) 185-200, 187.

'as Aristotle did of moral philosophy that a certain maturity of mind is necessary to overcome them successfully.'[31]

Tait's work in the various fields of mathematical physics is best illustrated by a contemporary impression.[32] In 1901, the year of Tait's death, former students of Tait had commissioned an illuminated address to celebrate Tait's retirement as Professor of Natural Philosophy at Edinburgh University. Tait died before the address could be presented, but his widow Margaret received it in his stead. Instead of celebration, the address became an object of contemplation. As such, it shows admirably how Tait was remembered and what kind of scientific man he was considered to be.

The illuminated address was an initiative of Tait's former students. No less than 63 of his most eminent students had signed the address. In the capable hands of Phoebe Anna Traquair (1852-1936), the first woman ever elected to the Royal Scottish Academy, the illuminated address became a work of art. Not only was it intended to praise Tait's merits as 'a teacher, an investigator, a writer and a moral force'[33], it also served as an emblem of Tait's 'scientific victories'.[34]

Traquair had taken great pains to portray Tait as a scientific hero: the address was decorated with interlinked knots –a reference to Tait's work on the typology of knots–, curves and diagrams from Tait's scientific papers on heat and dynamics, and images of various instruments designed by Tait himself, such as the deep sea thermometer, a gun used in pressure experiments, a radiometer, and a pendulum used by Tait in his studies

31 N.N., 'Death of Professor Tait', *The Times,* N.D.

32 For a shorter impression, see Tait's full bibliography either in: Knott, *Life and Scientific Work*, 351-365; or in: Chris Pritchard and David O Forfar, 'Bibliography of Peter Guthrie Tait', http://www.clerkmaxwellfoundation.org/References_to_Tait.pdf (23-05-2017).

33 Macfarlane, 'Peter Guthrie Tait', 62.

34 Ibid.

of ballistics.[35] Moreover, these symbols of Tait's 'scientific victories' were interspersed with the names of his closest scientific collaborators: James Dewar (1842-1923), Balfour Stewart (1828-1887), and William Thomson (1824-1907), who was made Lord Kelvin in 1892.[36] At the top of the address, two large scrolls prominently recounted Tait's most important work in mathematics and physics: the first scroll depicted a quaternionic formula, the other showed a thermodynamic diagram.[37] Dominating the address, however, was a large depiction of Sir Isaac Newton, who hovered over all Tait's scientific achievements, both experimental and mathematical. The image of Newton gave a sense of unity to the depicted individual elements of Tait's work. It signified above all that the person honoured in this illuminated address was, unmistakably, a man of science.

The image of Newton at the top of the address is very telling. It was intended, first of all, to underline Tait's dedication to the physical sciences and the great British tradition in general, but also, and more specifically, Newton's image referred to Tait's and William Thomson's collaboratively written *Treatise of Natural Philosophy* (1876), often referred to as *T&T'*, with Thomson as *T* and Tait as *T'*. As observed by historian of science Crosbie Smith in his *The Science of Energy*, *T&T'* was one of the written embodiments of the new science of energy and quickly became a standard text.[38] The treatise was designed to be used at the Mathematical Tripos and was aimed at a large reading audience.[39] In it, the authors redefined concepts like 'force', 'work' and 'energy', and so sought to base their theory

35 For Tait's work on projectile dynamics, see: Chris Denley and Chris Pritchard, 'The golf ball aerodynamics of Peter Guthrie Tait', *The Mathematical Gazette* 77 (1993) 298-313.

36 Tait and Balfour Stewart collaborated on two books on physics and metaphysics: Balfour Stewart and Peter Guthrie Tait, *The Unseen Universe: or Physical Speculations on a Future State* (London: Macmillan 1875); Balfour Stewart and Peter Guthrie Tait, *Paradoxical Philosophy: A Sequel to the Unseen Universe* (London: Macmillan, 1878).

37 Ibid. 62-63; Knott, *Life and Scientific Work*, 39-40.

38 Smith, *The Science of Energy,* 201-202.

39 For the importance of inclusion in the Tripos for the acceptance of new theories, see: Warwick, *Masters of Theory.*

on a solid, accurate and measurable footing.[40]

The science of energy originated in the North of Britain, and was conceived by a group of natural philosophers and experimentalists, including Thomson, Tait, Maxwell, Rankine and Henry Charles Fleeming Jenkin (1833-1885). Central to the pursuits of this North British group were commitments to the laws of conservation and dissipation of energy, and a belief that the universe should be understood 'as a universe of continuous matter possessed of kinetic energy', which stood in contrast to the beliefs of scientific naturalists, such as John Tyndall and Herbert Spencer.[41] Moreover, the proponents of the science of energy opposed deterministic views of the universe, and maintained commitments to free will and the possibilities of divine agency and divine design, echoing an older tradition of natural theology.[42] Tait himself was a prominent member of the North British group.

Tait and Thomson's *Treatise* should be seen as a condensation of the views of the energy physicists, and as a way of canonising them. The book claimed 'a Newtonian pedigree' for the new science, and offered a re-reading of Newton.[43] It was explicitly modelled on Newton's *Principia*, and its authors ambitiously claimed to 'expose the errors of previous scholars and restore to the text its 'original' meaning'.[44] Contemporaries recognised the Newtonian pedigree as well. Tait's former pupil Alexander Macfarlane, in one of his obituaries of Tait, described *T&T'* as 'the *Principia* of the nineteenth century'[45], while Cargill Gilston Knott quoted from multiple reviews of *T&T'*, all reflecting on the Newtonian character of the *Treatise*.[46]

As I have argued earlier, invoking the image of Newton in late

40 Smith, *The Science of Energy*, 201-202.
41 Ibid. 196-202.
42 P.M. Harman, *Energy, Force, and matter. The Conceptual Development of Nineteenth-Century Physics* (Cambridge: Cambridge University Press, 1982) 69.
43 Smith, *Science of Energy,* 196
44 Ibid. 193.
45 Macfarlane, 'Peter Guthrie Tait, his life and works', 195.
46 Knott, *Life and Scientific Work,* 186-190.

Victorian Britain, either on the illuminated address or in reviews of *T&T'*, had more meaning than simply alluding to the seventeenth century writer of the *Principia*. 'Newton' had become a shorthand for a virtuous way of conducting science in late nineteenth century Britain. One of the possible interpretations of 'Newton', according to Richard Bellon, emphasised the importance of the inductive, Baconian method in science and its guiding virtues of patience, courage, humility, and self-discipline.[47] Although other interpretations (like the ones offered by Tyndall or Spencer) tended to lean towards the genius side of Newton's character, the reviews of *T&T'* and Tait's illuminated address underline a perception of 'Newton' as the paragon of inductive, humble, patient and cautious science, in which the imagination played a secondary role.[48]

This perception of Newton is also prevalent in the memory culture surrounding Tait's death. Not only did Tait's biographers praise *T&T'* for being 'the *Principia* of the nineteenth century'[49], they also praised Tait for precisely those virtues that were associated with a methodical, laborious and humble Newton. In an obituary notice of Tait, Alexander Macfarlane described Tait as a man of genius, but then defined this genius as: working 'laboriously', 'zealously' and 'accurately' on experimental and mathematical problems.[50] Genius, in Macfarlane's conception, consisted of nothing more than a dedication to scientific method.[51] In a more in-depth obituary notice, Macfarlane stated that Tait was such a virtuous and productive man of science, because he 'was not easily induced to break in upon his routine', alluding again to the importance of disciplined laboriousness.[52]

47 Bellon, 'There is grandeur in this view of Newton', 222-224.
48 In 1855, for example, David Brewster had still stressed the genius of Newton, and his 'theoretical speculation' over his adherence to Baconian precepts: Higgitt, *Recreating Newton*, chapter 5, esp. page 138.
49 Macfarlane, 'Peter Guthrie Tait, his life and works', 195.
50 Alexander MacFarlane, 'Peter Guthrie Tait', 51, 52, 55, 58.
51 This was, in fact, an older view of genius, much in line with Joseph Priestley's conception of Newton's genius as perfectly following Baconian precepts: Yeo, 'Images of Newton', 264-266.
52 Macfarlane, 'Peter Guthrie Tait, his life and works', 188.

William Thomson, Tait's close collaborator on *T&T'* also reflected on Tait's 'faithfulness', his 'devotion' and 'purity of purpose', sentiments reflecting the importance of a selfless love for science.[53] Knott held a similar view of Tait's character, praising him for his 'patient determination'[54], his 'devotion'[55], and his enthusiastic laboriousness.[56]

Finally, an obituary written by Scottish mathematician George Chrystal lauded Tait's 'simplicity'[57], 'merry geniality'[58], and 'his staunch, almost quixotic, devotion to an approved cause'.[59] Chrystal also pointed towards Tait's behaviour in controversies and argued that Tait was always 'ready to take a blow' and that 'he did not always spare his strength in giving one'.[60] Chrystal stated that Tait's conduct in controversy was not borne of bitterness, but was a consequence of Tait's devotion. Once people became better acquainted with him, Chrystal continued, they would feel 'the magic of his personality'; ten minutes with Tait would make 'a friend of his bitterest foe'.[61]

Tait's biographers, to sum up, styled him as a virtuous man of science, modelled after the Newtonian ideal of humility, perseverance, devotion, patience and courage, despite his controversial positions. Tait's character united the disparate elements of his scientific career: his work in pure mathematics, experimental physics, education, and even metaphysics. It was only fitting that the image of Newton would stand proudly at the top of Tait's retirement address. In historiography, however, Tait is deemed less important than his contemporaries would have expected.

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53 William Thomson, 'Obituary notice of Professor Tait', *Mathematical and Physical Papers* VI (Cambridge: Cambridge University Press, 1911) 363-369, 368, 369.

54 Knott, *Life and Scientific Work*, 262

55 Ibid. 49.

56 Ibid. 90.

57 Chrystal, 'Professor Tait', 307.

58 Ibid. 305.

59 Ibid.

60 Ibid. 307.

61 Ibid.

Tait in historiography

A thorough biography of Peter Guthrie Tait is still lacking, although Tait figures occasionally in biographies of other Victorian physicists and in broader histories of Victorian physics or mathematics. In their seminal biography of William Thomson, Crosbie Smith and M. Norton Wise discuss Tait at some length, but only actually reflect on Tait's role in the life of Kelvin, and especially on their collaborative writing of *T&T'*.[62] Tait is assigned a larger portion of the text in Smith's broader cultural history of the science of energy, though the focus here is primarily on Tait's contributions to thermodynamics, his friendship with Maxwell, the writing of *T&T'*, and his defence of the energy principle against John Tyndall's appropriation.[63] Tait's work on the mathematical system of quaternions is mentioned only once.[64] Although Smith covers much ground, his discussion of Tait naturally emphasises his relation to the science of energy. P.M. Harman also discusses Tait in his monograph on the concepts of energy, force, and matter, but again, the discussion deals mostly with Tait's thermodynamics and his defence of the North British science of energy against intrusions by Tyndall and Mayer.[65] In Harman's biography of Tait's friend James Clerk Maxwell, the focus is again on Tait's relation to the subject of the monograph, and although Tait's contributions to both the study of quaternions and the science of energy are discussed, the author is mostly concerned with how Tait's ideas may have influenced Maxwell.[66] A broader account of Tait's contributions to science is provided by Daniel Brown in his *The Poetry of*

62 Crosbie Smith and M. Norton Wise, *Energy and Empire. A Biographical Study of Lord Kelvin* (Cambridge: Cambridge University Press, 1989), esp. 348-390.

63 Smith, *Science of Energy*, esp. chapters 9 and 10.

64 On page 208, mostly in relation to Thomson's antipathy towards Hamilton's quaternions.

65 P. M. Harman, *Energy, Force, and Matter,* esp. chapters III and IV.

66 Harman mentions Tait often –the first sentence of the introduction is a case in point-, but Tait is mostly employed as a lens through which we can see Maxwell more clearly. P.M. Harman, *The Natural Philosophy of James Clerk Maxwell* (Cambridge: Cambridge University Press, 1998) 1.

Victorian Scientists, but as the title suggests, much of the book is concerned with the relation between poetry and scientific style. Tait is mostly discussed as Maxwell's friend and as a subject of the latter's verses.[67]

At the same time, other scholars –mostly historians of mathematics– have written primarily on Tait's advocacy of the quaternions in mathematics and his opposition to vector analysis, thus marginalising Tait's work in the field of energy physics. Michael J. Crowe, in his book on the development of vector analysis, discusses Tait's work with William Rowan Hamilton (1805-1865), his influence on Maxwell, and his quarrel with Heaviside and Gibbs, but does not dwell on thermodynamics.[68] Chris Pritchard has also written mainly on Tait's contributions to quaternions and the discussions with Heaviside, Gibbs, Thomson and Maxwell on the merits of the quaternion method.[69] In addition, Pritchard has written a brief yet insightful exploration of the breadth of Tait's mathematical work on knots, golf ball dynamics and quaternions[70], and he has, together with David O Farfar, compiled a provisional bibliography of the works published by Tait.[71]

It seems that although Peter Guthrie Tait is generally regarded as an important mathematical physicist in late Victorian Britain, the literature focuses either on Tait's energy physics in collaboration with Maxwell or Thomson, or on his quaternion work, often in relation to subsequent vector analysts. Aside from Chris Pritchard's brief exploration, no writers have tried to connect all the fields in which Tait has worked to form a

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67 Daniel Brown, *The Poetry of Victorian Scientists. Style, Science and Nonsense* (Cambridge: Cambridge University Press, 2013), chapters 5 and 6.
68 Crowe, *A History of Vector Analysis*.
69 See: Chris Pritchard, 'Tendril of the Hop and Tendril of the Vine: Peter Guthrie Tait and the Promotion of Quaternions, Part I', *The Mathematical Gazette* 82: 493 (1998) 26-36; and: Chris Pritchard, 'Flaming Swords and Hermaphrodite Monsters: Peter Guthrie Tait and the Promotion of Quaternions, Part II', *The Mathematical Gazette* 82:494 (1998) 235-241.
70 Chris Pritchard, 'Aspects of the Life and Work of Peter Guthrie Tait, FRSE', http://www.clerkmaxwellfoundation.org/PritchardTaitBooklet.pdf (23-05-2017).
71 Pritchard and Forfar, 'Bibliography of Peter Guthrie Tait'.

balanced whole. While many of the better known scholars in Victorian Britain have been studied extensively in biographies –Maxwell, Thomson, Huxley, Hooker, Darwin, Galton, Frankland–, Tait has not received as much attention. Moreover, our knowledge of Tait is somewhat fragmented, with monographs positioning him either as someone zealously working on quaternions and as a Hamiltonian disciple, or as the co-writer of *T&T'* and the controversy-loving friend of Maxwell and Thomson. Finally, most approaches to Tait are rather internalistic: they deal mostly with the development of Tait's scientific ideas and contributions.

It is not my aim here to write a Tait biography, although it is long overdue. What this chapter can do, however, is to try and conjoin the fragmented picture we have of Peter Guthrie Tait, by focusing not on one aspect of his work, but by looking at Tait through the lens of his scientific character, or, to formulate it differently, his scientific *persona*.[72] Newton's prominent position in Tait's remembrance offers a clue to how Tait answered the question of what it took to be a scholar. The image of Newton, in Tait's case, referred to virtues of humility, perseverance, devotion, patience and courage; virtues commonly associated with the inductive method in Victorian Britain. Anyone not living up to Tait's standards of character was militantly mocked and charged with vices. It is to these vice charges that I will now turn.

72 A similar approach has been taken by Chaokang Tai and Jeroen van Dongen, who in their article on the Dutch astronomer Anton Pannekoek, sought to unite the Marxist and 'scientific' personae of Pannekoek through a study of epistemic virtues: Tai and Van Dongen, 'Anton Pannekoek's Epistemic Virtues in Astronomy and Socialism'.

Joule's experiments versus Mayer's genius

Peter Guthrie Tait and John Tyndall were each other's favourite adversaries.[73] They crossed swords repeatedly from the 1860s up until the late 1870s. Tait and Tyndall kicked off their years of animosity in the summer of 1862, when Tyndall delivered his lecture titled 'On Force' at the Royal Institution, in which he gave 'an *apparently* uncontroversial account of the principles of "force"'.[74] The lecture sounded uncontroversial –it discussed rather neutrally how force and mechanical effect were related and even occasionally used the term 'energy'–, but it held a surprise in store for the audience: at the end of the lecture, Tyndall ascribed the discovery of the principles of force, including the mechanical value of heat, to the German physicist Julius von Mayer (1814-1878).[75] This was utterly controversial, because British consensus had it that it was not Mayer, but James Prescott Joule who held priority in the discovery of the conservation principle. To make things worse, Tyndall went on to claim that even William Thomson 'had merely applied his admirable mathematical powers to the development of the theory.'[76] Tait and William Thomson, both intimately involved in the North British science of energy, and fierce defenders of Joule, could not help but respond to the attack on Joule's priority.

But more was at stake than simply Joule's priority. As Crosbie Smith shows, the clash between Tyndall, Thomson and Tait should be seen as a clash not between individuals, but between different ideals of science, and ways of practicing it. On the one hand, there was the North British group of energy scientists, with members like Tait, Thomson, and

73 There was some mutual respect between the two, although their printed debates would never show it. A letter sent to Edward Frankland in 1867 gossips about one of Tyndall's visits to Scotland: 'I am glad he [Tyndall] says that Thompson and Tait were friendly with him at Dundee or as he calls it like brothers!' See: Letter from Henry Bence Jones to Edward Frankland, 18 September 1867 [EFP, JRL, 12/1031].

74 Smith, *Science of Energy*, 180. Italics in original.

75 John Tyndall, 'On Force', *Philosophical Magazine* 24:158 (1862) 57-66, 64-65.

76 Smith, *Science of Energy*, 180.

Maxwell, who cherished the combination of thorough experimentation, rigid mathematical modelling, and a dedication to a tradition of natural theology. In doing so, they sought to claim an image of Newton as methodical, inductive, patient and laborious. On the other hand, there was the group of mostly London-based scientific naturalists –Huxley, Hooker, Tyndall, Frankland, and others–, closely associated with the X-Club, who had embraced Darwin's theory of evolution, militated against Christian doctrine, and sought to claim the principle of energy conservation for themselves.[77] Tyndall's denial of Joule's priority was a clear move, Smith observes, 'to shatter that North British monopoly' on the science of energy and to enforce the reputation of the metropolitan group.[78] Their conception of science hinged more upon imagination and creativity, and sought to sever the ties between natural theology and science prevalent in the North British approach. The contention about Mayer's priority, therefore, can be seen as a proxy for the competition between two different ideals of science: scientific naturalism versus the science of energy.

Tyndall's claim for Mayer's priority was based on the simple fact that Mayer had published a calculation of the mechanical equivalent of heat in 1842, one year before Joule had published his 'On the Mechanical Value of Heat'.[79] Joule, however, was generally recognised to hold priority, because he had *experimentally* ascertained the mechanical equivalent of heat, whereas Mayer had merely *hypothesised* that such a relation between work and heat existed. Interestingly, Tyndall couched his defence of Mayer in unmistakably moral terms, explicitly referring to Mayer's desire for science: 'a man of genius working in silence, animated solely by a love of his subject'[80], who came to his conclusions 'some time in advance of those whose lives were entirely devoted to Natural Philosophy.'[81] Mayer,

77 Ibid. 170-171.
78 Ibid. 182.
79 J.T. Lloyd, 'Background to the Joule-Mayer controversy', *Notes and Records of the Royal Society of London* 25:2 (1970) 211-225, 212.
80 Tyndall, 'On Force', 65.
81 Ibid.

Tyndall observed romantically, was a neglected genius and deserved greater attention for his 'beautiful and correct thoughts', and his 'profound imaginative insights'.[82] To Tyndall, then, Mayer's genius was to be valued higher than Joule's method.

Tyndall's lecture elicited a furious response from the North British group. Joule himself wrote angrily to Thomson that due to Tyndall being Professor of Natural Philosophy at the Royal Institution and successor to Michael Faraday, 'the walls of the Royal Institution might be almost expected to cry out against the neglect by the present Professor'[83], while Tait, in a private letter to Thomson, dubbed Tyndall 'the monster T'.[84] However, the outcry was not limited to private correspondences. In order to protect their science of energy and Joule's priority, the battle was made public.

Joule responded politely with a letter in his defence in the *Philosophical Magazine* a month later, in August 1862. He agreed that Mayer had played a role in the development of the dynamical theory of heat, but challenged Mayer's prominent position, by presenting a larger history of thinking about heat, and placing Mayer at the very end of that philosophical development. More importantly, Joule argued that Mayer's conclusions were essentially hypothetical: 'there were no known facts to warrant the hypothesis'.[85] Mayer's contribution, in other words, was just a lucky guess. Joule 'fearlessly' asserted his own priority in experimentally ascertaining the mechanical equivalent of heat.[86] Throughout the letter, he stressed his 'good conscience'[87] and the 'justness' of his claims.[88] Tyndall, in response, took up the gauntlet and repeated his previous claims. He

82 Ibid.
83 Lloyd, 'Background to the Joule-Mayer controversy', 215.
84 Ibid.
85 James Prescott Joule, 'Note on the History of the Dynamical Theory of Heat', *Philosophical Magazine* 24: 159 (1862) 121-123, 122
86 Joule, 'Note on the History of the Dynamical Theory of Heat', 122.
87 Ibid. 121.
88 Ibid. 122.

conceded to Joule's claim to the experimental validation of the mechanical equivalent of heat, but still retained his view that Mayer held priority, having conceived the hypothesis earlier than Joule did. This was not due to a 'haphazard guess'[89] on Mayer's behalf, but rather the result of careful deliberation by 'a man of rare ingenuity.'[90] By contrast, Tyndall described Joule as merely the 'experimental demonstrator of the equivalence between heat and work.'[91]

This implied first of all that Tyndall found the hypothesis of equivalence between heat and work to be far more important than its subsequent experimental demonstration, which was necessary, but was deemed neither original nor a mark of genius. Secondly, Tyndall's framing not only shows his prioritisation of hypothesis over observation, it also betrays his view of what qualities made a good man of science: Mayer was described time and again as an underappreciated genius of ingenuity, working solely for the love of his subject, while Joule was described as a 'demonstrator', characterised solely by persistence and hard labour.[92] There is a clear hierarchy in Tyndall's presentation: hypothesis above experiment, and the abstract genius above the methodical experimenter.

Although Joule was not content with Tyndall's response, he withdrew from public controversy. In his stead, Thomson and Tait took up arms by publishing an article on 'Energy' in the illustrated family magazine *Good Words* in October 1862. In this article Thomson and Tait reaffirmed their view of the history of the science of energy, Joule's rightful place therein, and (without explicitly mentioning Tyndall) downplayed the role of Mayer. Tyndall, however, was attacked implicitly, as Thomson and Tait wrote 'it especially startles us that the recent attempts to place Mayer in a position which he never claimed . . . should have support within the very

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89 John Tyndall, 'Mayer, and the Mechanical Theory of Heat', *Philosophical Magazine* 24:160 (1862) 173-175.
90 Tyndall, 'Mayer', 174.
91 Ibid.
92 Ibid. 173.

walls wherein Davy propounded his transcendental theories.'[93] According to Thomson and Tait, it was a case of depreciation and suppression of the claims of Joule. They attacked Tyndall, by implying that his position in the Royal Institution, where the venerable Humphry Davy and Michael Faraday had worked, was not a place fit for a man like Tyndall, who was clearly and viciously preoccupied with hypothesising, genius and ingenuity.

It took a while for Tyndall to respond and this was partly due to Thomson and Tait's choice for *Good Words*. The choice for a magazine of a popular and evangelical character, however, was sure to inflame the agnostic sentiments of Tyndall as soon as he found out, in March 1863, that he had been attacked in its pages. Again writing in the *Philosophical Magazine*, Tyndall expressed his annoyance: 'When however, it is known that the other articles in the number to which I refer, bear such titles as 'The Childhood of Jesus', 'The Trial Sermon' . . . 'At Home in the Scriptures', & etc., I think I may be excused if the article on Energy . . . imbedded in such matter as those titles indicate, escaped my attention.'[94] Moreover, Tyndall was explicitly infuriated by the 'imputations on individual character' and attacks on 'scientific morality' in such a popular magazine, and thought such accusations of vice below the 'dignity of science'.[95] He then repeated his view that the genius of Mayer was underappreciated in British scientific circles, and that the 'profound intuition' and 'undoubting conviction' of Mayer were at least on par with the 'steadfastness' of Joule.[96]

Tait was quite offended by both Tyndall's disqualification of the Christian journal *Good Words* as an arena for proper scientific discussion, and Tyndall's claim that Thomson and Tait unfairly attacked his character. Tait wrote to Thomson: 'I think we ought to crush him at once . . . I will do

93 William Thomson and Peter Guthrie Tait, 'Energy', *Good Words* 3 (1862) 601-607.
94 John Tyndall, 'Remarks on an Article entitled "Energy" in 'Good Words'', *Philosophical Magazine* 25:167 (1863) 220-224, 220.
95 Tyndall, 'Remarks', 221.
96 Ibid. 123; Tyndall added that 'the future historian of science will not, I think, place these men in antagonism.' I just proved him wrong.

it singly'[97] and wrote a letter to the *Philosophical Magazine*, addressed to the editor and not to Tyndall, in which he repudiated all the claims made by Tyndall. First of all, he wrote in defence of *Good Words*, turning Tyndall's argument against him, by stating that the latter had published an article in *Macmillan's Magazine*, 'which found publicity in the peculiar society of "Water Babies", "Sunken Rocks", and "Women of Italy".'[98] So, to start with, Tyndall was guilty of false accusations. Secondly, Tait launched a frontal attack on Tyndall's defence of Mayer's claims, and attributed this to a faulty character: 'Prof. Tyndall is most unfortunate in the possession of a mental bias', that prevented him from recognising the fact that Mayer's claims were already valued correctly, even before Tyndall's unnecessary intervention.[99] Finally, Tait completely shredded Mayer's claims by stating that Mayer had 'no claim to novelty or correctness', that he had simply stumbled upon the equivalent of heat and work 'by a lucky chance', and that he had proceeded from a 'utterly false analogy', and that even in these grave errors he was already anticipated by the French philosopher Séguin.[100] On the other hand, Joule had proceeded experimentally and inductively, which was the true mark of a man of science. Like Tyndall, Tait constructed a hierarchy of men of science, but in contrast to Tyndall's placement of the hypothesising genius above the laborious demonstrator, Tait reversed the positions: the great experimenter Joule stood well above the lucky and unoriginal Mayer.

Tyndall parried the hostilities immediately.[101] He addressed himself not to Tait, but to Tait's co-writer in *Good Words*, William Thomson. This was sure to absolutely boil Tait's blood, especially because Tyndall wrote as if Thomson was the adult responsible for Tait's childish behaviour in earlier letters:

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97 Lloyd, 'Background to the Joule-Mayer controversy', 217.
98 Peter Guthrie Tait, 'Reply to Prof. Tyndall's Remarks on a paper on "Energy" in 'Good Words'', *Philosophical Magazine* 25:168 (1863) 263-266, 264.
99 Tait, 'Reply', 264.
100 Ibid.
101 John Tyndall, 'Remarks on the Dynamical Theory of Heat', *Philosophical Magazine* 25:169 (1863) 368-378.

> You are the older and more famous man, and it is your behaviour in this controversy, and not that of your colleague, that will interest the scientific world. I trust, therefore, Prof. Tait will see that simple chivalry makes it my duty to decline entering into any contest with him at present; and seeing this, he will, I doubt not, have the grace and modesty to stand aside and allow you and me to settle this affair between ourselves.[102]

Tyndall continued to restate his earlier claims on the role of Mayer as the original investigator of the relation between heat and work, and Joule's position as mere experimental demonstrator, whose investigations still lacked 'the requirement of refined experimental inquiry', which signifies that Tyndall believed that even experimentalists should possess some of the ingenuity and creativity of Mayer.[103] Moreover, Tyndall went on to attack Thomson personally. Citing the article in *Good Words*, Tyndall stated that:

> There is not an idea of any originality in the whole of that paper that is not to be found in the memoirs of Mayer; and yet you do not give him an iota of credit in this article of yours in 'Good Words', the accuracy you have so trumpeted forth. . . . In the presence of such facts, it ill becomes you to talk to me of suppression and depreciation. . . . these utterances of you are not good words, but the reverse. Judged by the facts, and apart from your own misinformed convictions, they are not even words of truth.'[104]

These were grave accusations, even more so because they were aimed at Thomson's character, rather than his scientific work. He was accused of at least three vices: untruthfulness, inaccuracy and unoriginality. This could not continue.

Two responses came in the next edition of the *Philosophical Magazine*: one short notice by Thomson, and one letter by Tait. Both took

102 Tyndall, 'Remarks', 369.
103 Ibid. 376.
104 Ibid. 377.

the moral high ground following Tyndall's accusations of vice. Thomson signalled that Tyndall had gone too far this time: 'I consider it a great injury to myself . . . the tone adopted by Dr. Tyndall in addressing myself is of a character, I believe, unprecedented in scientific discussion. It is such that I decline to take part personally in any controversy with him.'[105] He added that Tyndall's choice to ignore Tait was completely unwarranted and injurious to both Thomson and Tait.[106] Tait's reply was longer and also rather polite, as he reiterated his earlier statements on the primacy of experiment over hypothesis: 'the general principle of the conservation of energy is founded on the experimental determination of relations of equivalence between the various forms of energy . . . and this was begun by Joule', while Mayer's paper 'contains in its fundamental statements an essentially false analogy . . . the method suggested by Mayer was a retrograde step, and tended only to introduce confusion.'[107] Tait refuted all claims made by Tyndall and suggested that the latter's partisanship had driven him to vices of inaccuracy and untruthfulness in his discussion of Joule. Tyndall answered neither Thomson nor Tait, which the latter took to be a 'tardy acquiescence' in the claims made by the two in favour of Joule's priority in discovering the mechanical equivalent of heat, by virtue of his experimental proof.[108] Tait presented this as a glorious victory, and Joule took the opportunity to thank the two in the same issue, for their 'ability and friendly zeal with which they have asserted my claims'.[109]

This meant that Tyndall's attack on the Northern science of energy had been successfully fended off. Joule remained one of the Northern heroes and stood firm as the man who had experimentally determined the relation

105 William Thomson, 'Note on Professor Tyndall's "Remarks on the Dynamical Theory of Heat"', *Philosophical Magazine* 25:170 (1863) 429.
106 Thomson, 'Note', 429.
107 Peter Guthrie Tait, 'On the Conservation of Energy', *Philosophical Magazine* 25:170 (1863) 429-431, 430.
108 Peter Guthrie Tait, 'On the Conservation of Energy', *Philosophical Magazine* 26:173 (1863) 144-145.
109 James Prescott Joule, 'On the Dynamical Theory of Heat', *Philosophical Magazine* 26:173 (1863) 145-147, 147.

between heat and mechanical work. Their discussion, however, sheds some light on more general themes as well. We can see clearly that the language of virtue and vice was employed regularly in these discussions. First of all, frequent accusations of vice were made in the exchanges between Tyndall, Tait, Thomson and Joule. Even when they claimed that it was wrong and even detrimental to the dignity of science to lambast someone personally, attacks on someone's lack of virtue were made overtly. Tyndall accused Thomson and Tait of vices of untruthfulness, unoriginality and inaccuracy, while in return, Tyndall was accused of exactly the same vices and even for having a 'mental bias' that kept him from seeing the truth of the matter. These accusations, however, were primarily aimed at the way in which each party to the argument conducted themselves and the goals each one had in mind throughout the controversy.[110]

Secondly, and more interesting for my point in this chapter, is how the question of who held priority in the discovery of the energy conservation principle was answered in terms of virtue and vice. Both Tyndall and Tait defended their claims in favour of respectively Joule and Mayer by promoting different specific constellations of virtues. Tyndall claimed fame for Mayer on the basis of Mayer's genial character, his imagination and his ingenuity, which were held responsible for his accurate approximation of the relation between heat and work. Joule, in Tyndall's view, merely affirmed Mayer's views through his laboriousness and devotion to his methodical experiments, but this was deemed less important than Mayer's leaps of imagination. Tait and Thomson, on the other hand, defended Joule's perception of science: careful, accurate experimentation was much more important than imaginative hypothesising, which depended ultimately on sheer luck, and in Mayer's case, was based on inaccurate and false assumptions. In their view, the laborious and accurate Joule stood well above the lucky and imaginative Mayer.

110 Vicious conduct in controversy will be discussed at length in the following chapter.

Both sides, however, did agree about what kind of science 'Joule' and 'Mayer' stood for, but they valued their orientations very differently. Joule, recognised by both sides to be an inductive experimenter, unimaginative yet patient and laborious, was praised by the North British energy scientists but scoffed at by Tyndall. Vice versa, Mayer was recognised by both to be an imaginative thinker, valued by Tyndall but deplored by Tait. If we take one step back and recall Herman Paul's observation that scientific *personae* were both points of contention and coordinates on a map of the discipline, we can see how both Joule and Mayer, at least in this debate, came to stand for specific ways of doing physical science in late Victorian Britain. Associating with one excluded association with the other and the boundaries between these *personae* were enforced through the accusation of vice.

Finally, central to both the configuration of 'Joule' and that of 'Mayer' was the role taken up by the imagination; Joule eschewed the imagination and came to his results through methodical virtues of patience, accuracy and laboriousness, while the genius Mayer disregarded precisely those virtues in favour of the imagination. This theme re-emerged a few years later during another discussion between Tyndall and Tait.

Tait versus Tyndall

The animosity between John Tyndall and Peter Guthrie Tait simmered on through the 1860s. Tait was busily working on *T&T*' with Thomson. The first edition appeared in 1867, and firmly entrenched the methodological and moral convictions of the Northern science of energy. The work, purposely written to be included in the Mathematical Tripos at Cambridge University, served not only as a way to carve into stone the essentials of the new science of energy, it was also intended to educate and shape the minds of young students at Cambridge. It was a showcase of what Thomson and Tait thought good 'Newtonian' science should look like, and taught young men how to be like 'Newton'. In a chapter on 'Experience', for example, Thomson and Tait juxtaposed the virtuous method of the experimenter to the method of 'hasty philosophers' who rushed to grand conclusions.[111] As in the controversy with Tyndall, they cherished virtues of 'endless patience and perseverance in designing and trying different methods' and advised that success was only attainable if an experimenter was 'not allowing himself to be disheartened by the non-success of one form' and 'judiciously varies his methods'.[112] Nature should be 'suspiciously' interrogated through repeated experiments and 'careful observation' so that 'inaccuracies' could be avoided.[113] Furthermore, the step from experimental results to expression in mathematical formulae was discussed in such a way that precision and accuracy was maintained.[114] In the following chapter, 'Measures and Instruments', the practical use of instruments and the best way to obtain accurate measurements were discussed. Again, virtues of 'accuracy', 'carefulness' and 'delicacy' recur repeatedly and were seen to safeguard a correct use of scientific instruments.[115]

John Tyndall, on the other hand, was busily working on his experiments on radiant heat and the molecular dynamics of matter, performing his many duties at the Royal Institution, and working with the other members of the X-Club to further the cause of scientific naturalism in Britain.[116] Like Thomson and Tait, Tyndall had great influence on generations of students via his position as Professor of Natural Philosophy at the Royal Institution. Like Thomson and Tait, again, Tyndall exploited this position to shape the character of his students. Unlike Thomson and Tait, however, Tyndall's emphasis lay not on the inductive character of science and its

111 William Thomson and Peter Guthrie Tait, *Treatise of Natural Philosophy* (Oxford: Oxford University Press, 1867) 442.
112 Thomson and Tait, *Treatise*, 443.
113 Ibid. 443-447.
114 Ibid. 454-456.
115 Ibid. 462, 464, 470, 472.
116 For an introduction to Tyndall's thought, see: Ursula DeYoung, *A Vision of Modern Science. John Tyndall and the Role of the Scientist in Victorian Culture* (New York: Palgrave Macmillan, 2011). For the X-Club and scientific naturalism, see: Ruth Barton, "An Influential Set of Chaps': The X-Club and Royal Society Politics, 1864–85', *British Journal for the History of Science 23* (1990) 53–81; and: Dawson and Lightman (eds.), *Victorian Scientific Naturalism*.

virtues of patience, self-discipline, accuracy and carefulness. Instead, he propagated an integrated approach towards scientific methodology, one that combined feats of induction and deductive thinking. Confronted with the Newtonian image as presented by Thomson and Tait, Tyndall chose another great man of science to represent his school of thought: Michael Faraday, his predecessor at the Royal Institution. Although Faraday's mantle did not always fit Tyndall well –Faraday was humble and moderate, even a devout Christian, where Tyndall was more assuming in his manner and sided with the scientific naturalists–, he did his best to wear it with pride.[117]

Upon Faraday's death, Tyndall presented his view of him in two lectures, later published together as *Faraday as a Discoverer* in 1868, one year after publication of *T&T'*. The biography offers an intriguing insight into Tyndall's conception of the ideal scholar and his claim to know the true character of Faraday.[118] Where Thomson and Tait cherished inductive traits and a Newtonian character, Tyndall presented Faraday in quite a different way: 'Faraday has been called a purely inductive philosopher. A great deal of nonsense is, I fear, uttered in this land of England about induction and deduction. Some profess to befriend the one, some the other, while the real vocation of an investigator, like Faraday, consists in the incessant marriage of both.'[119] Moreover, Tyndall stressed Faraday's hidden 'fire and that excitability', which he could only control through self-discipline.[120] Echoing his praise of Mayer, Tyndall continually underlined Faraday's genius, using terms such as 'magician', even stating that Faraday 'smells the truth' and that he came to his conclusions through 'wondrous insight and utterances which seem less the product of reasoning than of revelation'.[121] Faraday was not just a simple experimentalist, Tyndall claimed: 'Faraday was more than

117 DeYoung, *A Vision of Modern Science*, 78-85.
118 For a lengthier discussion of Tyndall's Faraday, see Cantor, 'Public Images of Michael Faraday', 173-177.
119 John Tyndall, *Faraday as a Discoverer* (London: Longmans, Green, &Co., 1868), 23.
120 Tyndall, *Faraday*, 38.
121 Ibid. 29, 45, 73.

a philosopher; he was a prophet, and often wrought by an inspiration to be understood by sympathy alone.'[122]

The hierarchy implied in Tyndall's appraisal of Mayer and Joule clearly returned in his Carlylean characterisation of the heroic Faraday. Faraday was much more than an inductive philosopher: he combined his prophetic genius with the self-discipline of the experimenter. Though not necessarily true to the real Faraday, this marriage befitted Tyndall well, as he sought to embody this image of Faraday. In Tyndall's hands, 'Faraday' came to stand for a constellation in which genius and imagination held primacy over method, accuracy and self-discipline. This, however, was not the only way in which Faraday was represented in Victorian Britain. An opposing image, more inspired by the self-help ethos of Samuel Smiles than by the Carlylean romantic view, was the 'realistic' image of Faraday, which stressed 'perseverance', 'industry' and his 'spirit of inductive inquiry', which was much closer to the ideals of Thomson and Tait.[123] Smilesian writers even criticised Faraday's more imaginative work: 'his genius only created useless castles in the air'.[124]

The tensions between the Newtonian image conceived by Thomson and Tait and the Tyndallic Faraday came to the fore again in the early 1870s, as Tyndall stepped up his scientific naturalist assaults on traditional Christian science and its dogmas. His aim was, as he expressed it himself in the preface to a collection of essays on the imagination, to 'dissipate the repugnance, and indeed terror' associated with the claims of natural science and 'legitimate scientific speculation'.[125] His goal was to counter the vices of fearful caution and repugnance, and he pursued this goal through various lectures on the use of the imagination in science, precisely the quality he had praised in both Mayer and Faraday. The first lecture on the imagination,

122 Ibid. 81.
123 Cantor, 'Public images of Michael Faraday', 186.
124 Ibid. 186.
125 John Tyndall, *Essays on the Use and Limit of the Imagination in Science*, 'explanatory note'.

given at the British Association for the Advancement of Science meeting at Norwich in 1868, did not generate much attention, but the second lecture on the subject, during the BAAS meeting at Liverpool in 1870 gave rise to furious comments, both inside and out of scientific circles.

The argument in the Liverpool lecture, 'On the Scientific Use of the Imagination', can be summarised in two sentences: men of science can explain a great deal through an appeal to observation and experiment, but legitimate speculation is needed in order to truly understand the nature of reality. Therefore, the imagination of the man of science is the most important faculty and takes precedent over the faculty of reason. Putting this theory into practice, Tyndall showed how he, through the scientific use of his imagination, could even legitimately speculate about the origins of life; concluding that life was once 'latent in a fiery cloud.'[126] In his address, Tyndall combined insights from the science of energy with a scientific naturalist defence of Darwin, evolution and the material origins of life.[127] In anticipation of the criticisms that would surely be uttered, Tyndall called on his listeners to employ virtues of 'courage' and 'manful willingness', rather than to recede into easy 'dogmatism', or to let 'the fear of error' preponderate over 'the love of truth'.[128]

His lecture, as calculated, led to an outcry of dissent from clerical circles. Reviewers from Christian magazines primarily attacked Tyndall's materialistic conclusions, and linked these conclusions to his personal character. One reviewer wrote in the Church of England periodical *The Record*: 'Such a philosophy, the child of unbridled pride of intellect, may

126 John Tyndall, 'On the Scientific Use of the Imagination', 35.
127 For more information on Tyndall's views on the reality of his molecular speculations, see: Maria Yamalidou, 'John Tyndall, the Rhetorician of Molecularity. Part One. Crossing the Boundary towards the Invisible', *Notes and Records of the Royal Society of London* 53:2 (1999) 231–242; and Maria Yamalidou, 'John Tyndall, the Rhetorician of Molecularity. Part Two. Questions Put to Nature', *Notes and Records of the Royal Society of London* 53:3 (1999) 319–331.
128 Tyndall, 'On the Scientific Use of the Imagination', 15, 35, 43, 44.

appeal to the wildest imagination of corrupted human nature, but it has not sympathy with all the higher yearnings of the soul.'[129] There was also a scientific response, voiced primarily by Peter Guthrie Tait in 1871. I have already alluded to this response at the beginning of this chapter, but I will elaborate further in these paragraphs.

Tait chose to publish a review in *Nature*, which was by then one of the journals in which highly controversial points could be fought out before a large scientific audience.[130] Interestingly, Tait did not attack Tyndall's materialistic conclusions head-on, although he surely disagreed with them. Instead, Tait criticised Tyndall's vicious lack of restraint in using the imagination –the balance was off.[131] Seen in the light of the earlier discussion between Tyndall and Tait on the merits of Joule and Mayer and their subsequent conceptualisations of the ideal scholar, Tait's attack on Tyndall's imaginative disposition should also be seen in the light of their competing definitions of what it took to be a scholar in the late nineteenth century.

Tait wrote: 'Professor Tyndall will eventually have much to answer for. He has lent his authority to the admission of imagination in the pursuit of science, and there is every prospect that people whose imaginative faculty is stronger than their habit of observation will give us all plenty to do.'[132] For Tait, Tyndall's plea for the imagination over 'habits of observation' was not a step forward in the progress of science, but a step back to the dark pre-Newton days: 'are we to live, scientifically, in the same way as alchemists and astrologers did in the Middle Ages? and are we to ignore all that Bacon and Newton have done for us?'[133] He conceded that creativity and the imagination were needed for men of science to pursue their goals, but again reversed Tyndall's hierarchy of imagination first, reason second: 'Let

129 N.N., 'Review of Tyndall's Lecture 'On the Scientific Use of the Imagination'', *The Record* (23 September 1870).
130 Baldwin, *Making "Nature"*.
131 Tait, 'Imagination in Science', 395.
132 Ibid.
133 Ibid.

us use the imaginative faculty by all means; but, in doing so, let us take our stand on the firm ground of the known before we venture ourselves into the unknown.'[134]

It is interesting to see, that Tait immediately took up the names of Newton and Bacon to fight for his cause. Tait's 'Newton' and 'Bacon' were shorthand for the inductive method and virtues of patience, accuracy and the disciplining of the imagination. For Tait, the only reasons the 'Middle Ages' ended, were the revolutions of Bacon and Newton, which not only offered a new way of looking at the universe, but, more importantly, a new way of being a scholar. This new scholar was characterised by a disciplining of the self, the laborious and accurate application of method and the restraining of the imagination.[135] Tyndall, on the other hand, could not base himself on these images of scientific worth, and instead sought others to do his bidding for him. The German poet Goethe, for example, figured prominently in Tyndall's address, as did Charles Darwin. The former was praised for his 'genius'[136], while the latter became a brilliant example of how to use the imagination: 'In the case of Mr. Darwin, observation, imagination, and reason combined have run back with wonderful sagacity'.[137] As in his characterisations of Mayer, and indeed Faraday, Tyndall framed Darwin and Goethe as geniuses, who could combine great intuitive and ingenious insights with accurate observations. For both Tait and Tyndall, it was all about balance: should the imagination be given leeway, or should it be disciplined?

Tait's critique on Tyndall's lecture, however, went further beyond

134 Ibid.

135 This view of Newton and Bacon was more popular, Richard Yeo argues, in the first decades of the nineteenth century, but gradually gave way to a view that downplayed the Baconian precepts and stressed the imaginative character of Newton's discoveries. In other words, Tait embedded himself in an older, more common-sense tradition with regard to the meaning of Bacon and Newton, which was more easily reconciled with his adherence to natural theology. See: Yeo, 'An Idol of the Marketplace', 267-280.

136 Tyndall, 'On the Scientific Use of the Imagination', 3.

137 Ibid. 31.

the virtues, or vices, that each man claimed to be important in science. Both of them also reflected on matters of devotion. Tyndall, lashing out against his more conservative and dogmatic colleagues, whom he called 'Tories in science'[138], stated in his lecture that: 'they do not lack the positive element, namely the love of truth, but the negative element, the fear of error, preponderates.'[139] They were motivated by fear, and not by the all-important love of truth, and this impeded their judgment. Tait also claimed this moral high ground and argued with respect to Tyndall's 'speculations' that 'for people who feel that they must walk over the earth in search of truth, nutriment of this kind is by no means sufficient.'[140] He added that Tyndall's vices might have grown from his desire to take 'a road through the air' to knowledge.[141] Both Tait and Tyndall claimed the love of truth for their own position.

This remark echoes another accusation that Tait had frequently made against Tyndall and others belonging to the metropolitan group of scientific naturalists: the criticism that they were not motivated by scientific concerns, but by a 'morbid craving for excitement.'[142] Although the article in which Tait wrote this, 'Sensation and Science', does not explicitly mention Tyndall, the fact that it appeared in the same year as Tait's reply to Tyndall's lecture on the imagination, that it was aimed at another lecturer at the Royal Institution, and that it reiterated several of the key points in Tait's earlier critique, suggests that Tait remained on the offensive towards scientific naturalism and its vicious lack of restraint.[143]

Moreover, Tait had frequently referred to Tyndall as a popular lecturer, and this article can therefore be interpreted as a critique on Tyndall's practices as well. In a source that I discussed before in the section on fame in chapter 1, Tait's review of Rev. Prof. Haughton's book on *The Principle*

138 Ibid. 16.
139 Ibid. 35.
140 Tait, 'Imagination in Science', 395.
141 Ibid.
142 Tait, 'Sensation', 177-178
143 See also Brown, *Poetry of Victorian Scientists*, 128-131.

of Least Action, Tait called out Haughton's 'morbid craving for excitement', which was 'characteristic of mental indolence', and which Tait saw as a 'contamination' of science.[144] Characteristics of 'sensation', according to Tait, were the facts that the writer left 'strictly mathematical applications' and plunged 'headlong into a wild sea of speculation, without previous careful definition of his terms'[145], being 'loose and slipshod' in language and mathematics[146], and displaying 'ignorance' of (better) work by previous authors.[147] This criticism echoed Tait's critique of Tyndall's speculations, made without basing himself 'on the firm ground of the known'. I argued in the first chapter that Tait's arrows were aimed at the vices exemplified by Haughton: a speculative use of the imagination and the want for excitement. I want to add now that these charges did not just apply to Haughton, but to Tyndall (Haughton's colleague at the Royal Institution) as well.

This firm ground of the known, as is observed by Daniel Brown, was formed both by the results of thorough experimentation, and by its conceptualisation in strict mathematical formulae. This was another North British point of critique on Tyndall: 'he was not a Wrangler', whereas Thomson, Maxwell and Tait were.[148] A lack of mathematical definiteness on Tyndall's behalf became a sign of scientific sensation in Tait's eyes. The linkage of popular sensationalism and the lack of mathematics and experiment in Tyndall's work was also expressed by James Clerk Maxwell, who loved to write in verse, and also attributed several verses to the feud between the mathematical Tait and the popular Tyndall:

> For Tait comes with his plummet and his line,
>
> Quick to detect your
>
> Old bosh new dressed in what you call a fine

144 Tait, 'Sensation', 177.
145 Ibid.
146 Ibid.
147 Ibid. 178.
148 Brown, *Poetry of Victorian Scientists*, 115.

Popular lecture

. . .

But see! Tait writes in lucid symbols clear

One small equation;

And Force becomes of Energy a mere

Space-Variation[149]

The claiming of strict and definite mathematical language for the cause of the North British science of energy was also another claim on Newton's legacy, who had, after all, devised the new calculus. The Tyndallic praise of imagination, creativity and genius was interpreted as an attack on this Newtonian ideal and was attributed to a desire for sensation, popularity and excitement. Tyndall, on the other hand, saw Thomson and Tait's stance as motivated by a fear of error, rather than by a love of truth, and himself cherished the imaginative genius of Faraday and Darwin over the inductive and fear-mongering dogmatism of the North British science of energy.

Two observations can be made on the basis of the above debate. First of all, Tait and Tyndall disagreed about the role the imagination should play in science, and, more specifically, which virtues should be cultivated. This was a question of balance: Tyndall lacked restraint, while Tait was excessively cautious. Secondly, the debate shows that the two assailants attacked not only each other's constellation of virtues, but also each other's love of science. Tyndall, Tait argued, was motivated by a morbid craving for excitement, while Tait was accused of fearing error more than he loved science. Both points are reminiscent of the common ground I sketched in the previous chapters: balance and a love of truth were thought to be remedies against vice. The debate between Tyndall and Tait shows that a perceived imbalance and inappropriate desires resulted in vice charges.

149 The full poem is cited in: Brown, *Poetry of Victorian Scientists*, 118–121.

Tait versus Ingleby

The role of mathematics in Tait's ideal of science was that it described nature in the most accurate and definite way possible. Although experiments and observations were the raw inductive resources for natural science, mathematics was the only language suitable to go beyond the observations and experimental results in order to arrive at a more general theory. In claiming this role for mathematics, as we have seen, Tait also claimed the Newtonian image as one which combined observation, experiment and generalisation in the one way in which that was possible: through rigid and definite mathematical conceptualisations, the influence of imaginative fancies was kept to a minimum.

Speaking of Newton's calculus, however, also brings to mind the old controversy between Isaac Newton and Gottfried Wilhelm Leibniz (1646-1716) over who had first invented the method of calculus in mathematics. It is now clear, as A. Rupert Hall writes in his book on the controversy, that 'it was certainly Isaac Newton who first devised a new infinitesimal calculus and elaborated it into a widely extensible algorithm', but that it was of 'equal certainty, the differential and integral calculus . . . was created by Gottfried Wilhelm Leibniz.'[150] In the late nineteenth century, however, this was not clear at all, and the quarrel between the German philosopher and the British philosopher was marked by an afterlife full of controversy and bad blood between German and British advocates of the one priority over the other.

Chauvinism played a major role in the discussions over the merits of both Newton and Leibniz, as both British and German writers sought to claim national aggrandisement for association with the calculus that did so much to improve scientific progress. In the late nineteenth century, with German science in the ascendant, the image of the British hero Newton was in need of protection and assertion. Peter Guthrie Tait, staunch defender of

150 A. Rupert Hall, *Philosophers at War. The Quarrel between Newton and Leibniz* (Cambridge: Cambridge University Press, 1980) 1.

his view of 'Newton', and often accused of being motivated by chauvinism[151], was found on the ramparts in the early 1870s, attempting to defend his image of Newton against intrusions from the side of metaphysicians, in a debate with the lawyer and metaphysician Clement Ingleby, who sought to rehabilitate Leibniz's claims. Through Leibniz and Newton, Ingleby and Tait discussed the ideal relationship between mathematics and metaphysics, and the role to be played by the imagination in the two. In their discussion, at least on Tait's side, chauvinism and national character also played a major role, as Tait sought to claim the virtuous Newton as a national symbol to counter all too metaphysical German science as symbolised by Leibniz.

The debate was provoked by Tait on the 17th of May 1879, when he read a paper on 'Hegel and the Metaphysics of the Fluxional Calculus', written by his assistant William Robertson Smith (1846-1894).[152] The paper was more or less a refutation of Hegel's views on Newton's calculus, interspersed with accusations of vice on Hegel's account. Terms such as 'self-complacent arrogance', 'shallow empiricism', 'self-conceited dogmatism' and 'vague pomposities' recur often and were employed to ridicule Hegel, who lacked a proper mathematical basis.[153] But the paper was not solely aimed at a refutation of Hegel's views on Newton. Its aims were more urgent, because in recent years Hegel was becoming more and more influential 'on British speculation'.[154] Moreover, Smith stated that metaphysical science was on the rise as well, and that the hubristic 'assumption of omniscience' on their part was very troubling for the progress of science as a whole, because the Hegelian approach was so imperialistic: it provided answers not only to metaphysical questions, but to physical and mathematical ones as well.[155] Smith was worried, and having read the paper, so was Tait. After reading

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151 See for example Knott, *Life and Scientific Work*, 225.
152 W. Robertson Smith, 'Hegel and the Metaphysics of the Fluxional Calculus', *Transactions of the Royal Society of Edinburgh* 25 (Edinburgh: Robert Grant & Son, 1869) 491-511.
153 Ibid. 505
154 Ibid 491.
155 Ibid.

the paper and adding his own comments, Tait drew the boundaries between metaphysics and mathematics even more strictly, and argued that it was impossible for a metaphysician to also be a proper mathematician. The two were mutually exclusive, and it was clear that Tait preferred one to be a mathematician.[156] He even challenged the audience and the 'metaphysical world' at large 'to produce a metaphysician who was also a mathematician', and could not think of such a person himself.[157] By drawing such firm boundaries, Tait hoped to save inductive science from being contaminated by metaphysical speculations, which were characterised by the above-mentioned vices of shallowness, self-conceit and complacency.

Clement Ingleby, who taught logic and metaphysics at the Birmingham and Midland Institute, felt urged to respond to Tait's attack on metaphysics, calling it 'a confusion of thought respecting the intellectual ranks of mathematicians and metaphysicians.'[158] In response, Ingleby argued that there were three types of mathematicians (inventors, experts and students), and only two types of metaphysicians (creators and students). Having cleared up his definitions, Ingleby took up Tait's challenge and argued that both former classifications (mathematical inventors and metaphysical creators) could very well be combined in a single person, and that at least Descartes and Leibniz would qualify: they had both invented new mathematical approaches and constructed metaphysical systems. The simple fact that Tait had missed these two eminent names was the result of 'ignoration on the part of the Scotch mathematician . . . that challenge was doubtless intended as mere *badinage,* at the expense of a science which he had taken no pains to understand.'[159] Moreover, Ingleby added that it would indeed be very fruitful if mathematics and metaphysics would come closer together, and declared anyone who opposed that view, as Tait did, to

156 Peter C. Kjærgaard, 'Migraine and Metaphysics: Sentinels of Science in Nineteenth-century Physics', *Journal of Cambridge Studies* 5:4 (2010) 1-15, 2.

157 Cited in: C.M. Ingleby, 'Creators of Science', *Nature* 5 (23 November 1871) 62.

158 Ingleby, 'Creators of Science', 62.

159 Ibid.

be 'the enemy of intellectual progress, who delights in setting the one class of investigators against the other.'[160] Not only were Tait's views wrong, he was also motivated by a masochistic delight in sowing discontent within science.

Tait, accused of being an enemy of science, responded within a week and called Ingleby's personal attack 'appalling' and the work of 'a strategist of no mean order.'[161] On a less personal note, Tait repudiated Ingleby's trichotomy of mathematicians: 'The man is either a Mathematician or a Non-Mathematician'.[162] Being a mathematician was much easier than being a mathematical inventor, and so people like William Thomson and James Clerk Maxwell also qualified as mathematicians in Tait's view. As regards metaphysics too, Tait proposed a different distinction to that of Ingleby: 'genuine' metaphysicians and 'spurious' metaphysicians.[163] Names in the first category were deemed properly scientific and included mathematicians and physicists such as Descartes, Hamilton and many more. Leibniz, however, was harshly excluded from the list, because he was 'simply a thief as regards Mathematics, and in Physics he did not allow the truth of Newton's discoveries.'[164] Illegitimate, or 'spurious' metaphysicians, on the other hand, were arrogant imposters, 'dwellers in a sublime sphere', pompous and prideful system builders that offered nothing but nonsense.[165] Leibniz belonged to that group. In Tait's eyes, those who saw themselves as 'metaphysicians', almost exclusively belonged to the latter class, while proper mathematicians and physicists were the genuine kind of metaphysicians. The opposition between genius and method thus played a major role in Tait's boundary work between mathematics and metaphysics. The former could be pursued by anyone skilled in mathematics, whereas

160 Ibid.
161 Peter Guthrie Tait, 'True and Spurious Metaphysics', *Nature* 5 (30 November 1871) 81.
162 Tait, 'Metaphysics', 81.
163 Ibid.
164 Ibid.
165 Ibid.

the latter was a pseudo-science, pursued by unaccountable and viciously prideful imposters. Metaphysicians, in other words, did not pursue truth, but rather their own imaginative fancies.

Tait's derogative response prompted Ingleby to defend himself and the metaphysics he represented. For the sake of argument, Ingleby followed up on Tait's classification, and showed that it offered some 'surprising results'.[166] First of all, in Tait's view Descartes was deemed a mathematician, while in Ingleby's eyes Descartes would qualify both as a bad mathematician and a 'spurious' metaphysician.[167] Secondly, and more importantly, Tait's treatment of Leibniz as a non-mathematician and a mere thief of Newton's theories was grossly unfair in the eyes of Ingleby, and simply incorrect: 'this charge is made just twenty years too late. It is exactly that time since the last vestige of presumption against the fair fame of the great German was obliterated.'[168] Ingleby spoke firmly in defence of Leibniz –a matter he thought had already been cleared up– and again questioned Tait's judgment on this matter.

At this point, the debate took another turn. Where Ingleby and Tait had disagreed on the relative merits of metaphysics and mathematics, the debate now started to focus on the character of Leibniz. In a later contribution, Ingleby repeated his conviction that Leibniz was a true mathematician and stated that he revered 'the name and intellect of Leibnitz, and I, for one, have a human interest in clearing that name from a foul slander.'[169] What 'Newton' was to Tait, 'Leibniz', as this quote suggests, was to Ingleby: an *exemplar* of what a good metaphysician or mathematician should be. Tait, on the other hand, reiterated his claim that Leibniz had stolen Newton's calculus, accusing him of being 'dishonest' and calling his behaviour 'suspicious'.[170]

166 C.M. Ingleby, 'Leibnitz and the Calculus', *Nature* 5 (14 December 1871) 122.
167 Ingleby, 'Leibnitz', 122.
168 Ibid.
169 C.M. Ingleby, 'Leibnitz's Mathematics', *Nature* 19 (23 January 1879) 267.
170 Tait, 'Leibnitz's Mathematics', *Nature* 19 (30 January 1879) 288.

This in turn prompted Ingleby to clear Leibniz's good name. He called upon the Royal Society to reopen the investigation into the Leibniz and Newton controversy and to release the papers on the basis of which the priority was decided. Only if these papers would be reread, 'evidence to character' could become a factor in the appraisal of Newton and Leibniz.[171] Responding, again within a week, Tait found Ingleby's sudden call for a reopening of the investigation into Newton and Leibniz rather surprising, because Ingleby had said earlier that 'the last vestige of presumption' against Leibniz had been obliterated twenty years ago. Having backed Ingleby into a corner, Tait delivered the final blow by citing the 'true metaphysician' Kant's opinion of Leibniz, who compared Leibniz to people who 'gave themselves out to be possessed of secrets, when they had really nothing but a persuasion and a conviction of their capacity for acquiring such.'[172] Leibniz, in Kant's eyes, did not proceed inductively but intuitively –the mark of a spurious metaphysician–, and was quite dishonest about his findings at the same time.

The fact that both Ingleby and Tait discussed the question of Leibniz's or Newton's priority in inventing the calculus in terms of 'evidence of character' is very striking. Tait's argument against Leibniz was not only motivated by his disdain for deductive metaphysics and the imagination, it was also intended to reassert the claims of the North British science of energy on a Newtonian character; if Newton was not solely responsible for the new calculus, then the claims of a Newtonian pedigree would certainly be diminished. The list of Tait's scientific heroes –Joule, Thomson, and of course Newton–, necessitated a list of anti-heroes, or villains. Joule was the antithesis of Mayer, Tyndall of Thomson, and finally, the dishonest and metaphysically arrogant 'Leibniz' stood against the inductive and mathematical 'Newton'. As a lecturer in metaphysics, Ingleby's status relied heavily on Leibniz's status as metaphysician and proper mathematician.

171 C.M. Ingleby, 'Leibnitz and the Royal Society', *Nature* 19 (20 February 1879) 364.

172 Peter Guthrie Tait, 'Leibnitz's Mathematics', *Nature* 19 (27 February 1879) 384.

As he said himself, he had a 'human interest' in clearing Leibniz from Tait's foul slander. To conclude this section, then, I hope to have shown that the quarrel between Newton and Leibniz led a surprising afterlife in a late nineteenth-century discussion between Tait and Ingleby. Leibniz was invoked either as an *exemplar* or as a villain, depending on who was asked.

Finally, both Tait and Ingleby attributed different constellations of virtues and vices to 'Leibniz'. As far as Tait was concerned, 'Leibniz' stood for a combination of vices: dishonesty, pride, arrogance, and reliance on intuition. In Tait's eyes, 'Leibniz' was a landmark on the 'map' of science that was to be avoided at all costs in favour of 'Newton'. By ascribing vices to Leibniz, Tait drew imaginary boundaries between good and bad science. As in the disputes with Tyndall, the imagination plays a central role in these accusations: Leibniz's metaphysics was too imaginative, whereas Newton had successfully disciplined and guided his imagination.

Tait versus Spencer

Between 1873 and 1880, Tait fell out with another member of the X-Club, the philosopher and metaphysician Herbert Spencer. Again, the discussion focused on metaphysics, experiment and intuition. Again, Newton's image and the *Principia* were invoked. What distinguishes this case from the previous cases, however, is the fact that both Tait and Spencer sought to claim Newton for their own purposes: Spencer employed Newton to support his argument that all basic physical truths were to be grasped *a priori*, while Tait claimed Newton to show that induction, experiment and observation lay at the basis of physical truths. The debate on *a priori* reasoning that was fought out between Spencer and Tait can therefore also be seen as a renegotiation of Newton and a frontal attack by Spencer on the Newtonian pedigree claimed by Thomson and Tait in their *T&T*'.

The controversy started with an anonymous review of Herbert Spencer's *First Principles*, *Principles of Biology*, and *Principles of Psychology* in October 1873.[173] The reviewer was rather critical of Spencer's work, but, according to Spencer himself, 'not wholly unsympathetic'.[174] Spencer therefore took time to refute the criticisms made on his philosophical system by the anonymous reviewer. The reviewer deplored the fact that metaphysicists like Spencer undermined physical and inductive science by placing their *a priori* metaphysical systems above 'all experimental evidence'.[175] In response, Spencer confirmed the fact that *a priori* reasoning took precedent over experimental evidence, and in the process, he touched upon Thomson and Tait's *T&T'*.[176]

The reason for drawing in Tait and Thomson was that the anonymous reviewer had invoked a remark by Tait, namely that 'Natural philosophy is an experimental, and not an intuitive science. No *a priori* reasoning can conduct us demonstratively to a single physical truth.'[177] We have already seen that this was Tait's conviction; in all controversies thus far, he had underlined the centrality of experiment to natural science and warned against too great an influence of the imagination. Herbert Spencer, on the other hand, called this remark 'rather doubtful' and 'imperfect', because the question of experiment versus *a priori* reasoning was not a matter of physics, but a question 'respecting the nature of proof', in which Tait's judgment of the matter bore far less weight.[178] Spencer took it even further by attacking both *T&T'* and its framing of Newton's *Principia* as a feat of inductive science. It was rather odd, Spencer stated, that Tait asserted that 'no *a priori* reasoning' could lead to physical truths, when at the same time, Tait took Newton's laws of motion 'as basis for Physics', which were,

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173 N.N., 'Herbert Spencer', *British Quarterly Review* 58 (October 1873) 472-504. Ruth Barton later identified the writer as J.F. Moulton, a mathematician: Ruth Barton, 'Scientific Authority and Scientific Controversy in *Nature*: North Britain against the X Club', in: Louise Henson et. al. (eds.), *Culture and Science in the Nineteenth-Century Media* (Aldershot: Ashgate, 2004) 223-235, 235.

174 Herbert Spencer, 'Replies to the Quarterly Reviewer', *The Popular Science Monthly* (March 1874) 541-552, 541.

175 N.N., 'Herbert Spencer', 477.

176 Spencer, 'Replies', 548-552.

177 Ibid. 548.

178 Ibid.

in Spencer's view at least, literal *a priori* 'physical truths'.[179] Newton's laws simply could not be established *a posteriori*, Spencer claimed, and so it was 'not a little remarkable' that Tait spoke of the primacy of experiment 'when he has before him the fact that the system of physical truths constituting Newton's "Principia", which he has joined Sir William Thomson in editing, is established by *a priori* reasoning.[180] Tait had misunderstood Newton, and the mantle belonged ultimately to Spencer.

Tait wrote to *Nature* immediately, questioning the 'mental attitude' and 'preposterous notions' exhibited by Spencer. As such, Tait was echoing the accusation of a vicious 'mental bias' made against Tyndall. The reply was rather brief and amounted to a mockery of Spencer's skills in mathematics, which Tait compared with that of an oblivious undergraduate student.[181] It seems however, that Tait either misunderstood Spencer's argument or consciously avoided his main points, because the attack was mostly focused on Spencer apparently doubting the reality of the laws of motion, while in his article, Spencer had only disputed the epistemological grounds for those laws.[182] Tait's reply once again prompted a response by Spencer, who reiterated his conviction that 'there are *a priori* mathematical truths . . . so are there *a priori* physical truths' that were 'enunciated by Newton as such' and even 'adopted by Professor Tait as such'.[183] Spencer thus claimed that Tait did not understand Newton's reasoning and that even he himself was engaged in *a priori* 'intuitions', even though he militated against such reasoning.[184]

In the same issue of Nature, the anonymous reviewer from the *Quarterly Review* took up arms in favour of Tait and the latter's framing of

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179 Ibid 549.
180 Ibid. 550.
181 Peter Guthrie Tait, 'Herbert Spencer versus Thomson and Tait', *Nature* 9 (26 March 1874) 402-403.
182 Baldwin, *Making Nature*, 44.
183 Herbert Spencer, 'Prof. Tait and Mr. Spencer', *Nature* 9 (2 April 1874) 420-421, 420.
184 Spencer, 'Tait and Spencer', 420.

Newton's merits, in an article titled 'Herbert Spencer versus Sir. I Newton'. He wrote: 'neither Prof. Tait nor myself are, after all, treated so cruelly as is Newton, who, though his life was spent in maintaining the experimental character of all physical science, is cited as an authority for the *a priori* character of the most important of all physical truths – the well-known Three Laws of Motion.'[185] Moreover, Spencer's cruel treatment of Newton was the result of Spencer's metaphysical dogmatism; the reviewer advised him to 'dogmatise either less elaborately or less rashly about the views of a philosopher like Sir. I. Newton.'[186] Again, an accusation of vice was used in a debate to discredit someone's view of the ideal scholar. The debate simmered on through 1873 and 1874, and even though Tait had withdrawn from the debate, Spencer's perceived attacks on Newton and his alleged 'intensely unmathematical' disposition were continuously deplored in *Nature's* pages. Spencer even wrote to the editor of *Nature*, Norman Lockyer, that he had been treated unfairly.[187] Tait, on the other hand, was quite content with Spencer's shredding in the pages of the journal, not in the least because this felt like revenge on Tyndall as well, for he too wrote to Lockyer, in verse form:

> We'll see in a jiffy if this Mr. S[pencer]
>
> Has the ghost of a claim to be thought a good fencer.
>
> To my vision his merits have still seemed to dwindle.
>
> Since I found him allied with the great Dr. T[yndall]
>
> While I have, for my part, grown cockier and cockier,

185 The Author of the Article in the British Quarterly Review, 'Herbert Spencer versus Sir I. Newton', *Nature* 9 (2 April 1874) 421. Confusingly, the anonymous author of this article published under the name 'The Author of the Article in the British Quarterly Review'.

186 Author, 'Spencer versus Newton', 421.

187 Baldwin, *Making Nature*, 45.

Since I found an ally in yourself, Mr. L[ockyer][188]

Again, the discussion between adherents to different conceptions of science was fought out with reference to, firstly, the personal character of those involved and the virtues and vices they exhibited, and secondly, with reference to the Newtonian image in Victorian science and the virtues attributed to him.

In 1880, however, the debate ensued, as Herbert Spencer published a new article dealing with criticisms of his theories, specifically those uttered earlier by Tait and the mathematician Thomas Kirkman.[189] In the article, Spencer began by repeating the argument he had made earlier: mathematical and physical truths cannot be established experimentally, but rather only through *a priori* reasoning. This view, he thought, was confirmed by Newton's establishment of the laws of motion.[190] Secondly, Spencer attacked Tait for misunderstanding the principles of evolution that he had articulated in his work. More importantly, however, Spencer reflected on the reasons for Tait's disagreement with this position, attributing this to flaws of character and 'mental peculiarities', 'idiosyncrasies of thought', and a faulty 'habit of mind'.[191] Spencer argued that Tait's judgment was very inconsistent, and that he had a 'curious mental trait' that made him 'incapable of distinguishing' between a position communicated by Spencer himself and a caricature of this position constructed in Tait's own mind.[192] Tait would do well, Spencer believed, to strengthen his 'analytical faculties',

188 The verse is cited fully in Baldwin, *Making Nature*, 46. Moreover, Baldwin makes the point that the X-Club, to which both Spencer and Tyndall belonged, no longer saw *Nature* and Lockyer as an ally in their naturalistic ambitions, partly as a consequence of Spencer's treatment.

189 Herbert Spencer, 'Criticisms Corrected: I. Tait and Kirkman', *The Popular Science Monthly* (October 1880) 795-801. Kirkman had attacked Spencer's formula of evolution and made a mockery of it: John Offer, *Herbert Spencer and Social Theory* (New York: Palgrave Macmillan, 2010) 152.

190 Spencer, 'Criticisms Corrected', 795-796.

191 Ibid. 795.

192 Ibid. 799-800.

and to take a lesson in 'mental discipline' from Spencer.[193] Furthermore, Spencer attributed the vices of 'men of letters' to Tait, arguing that Tait lacked the scientific ability to look beyond the particularities of his research, because he missed 'a synthetical habit', which caused this 'defects of judgement'.[194] Thus, Spencer attacked not only Tait's experimental methodology, but attributed this to Tait's vices: a lack of mental discipline, poor judgment and inconsistency. Moreover, Spencer again claimed the Newtonian image for his own purposes by downplaying the virtues of the inductive method and championing the Newtonian imagination instead.

Tait, in response, attacked both Spencer's accusations of vice and his appropriation of Newton with recourse to even more accusations. He accused Spencer of 'habitual laziness', 'mental peculiarity' and a 'desire to appear to know where knowledge is not', of 'speculation' and trying to 'dogmatise' on his metaphysical system, of lacking 'accuracy' and, most importantly, for arrogantly positioning his own metaphysical system of evolution on the same level as Newton's laws: 'He puts his Formula of Evolution alongside of the Law of Gravitation!'[195] A week later, Spencer repeated his defence of *a priori* reasoning, and attributed Tait's failure to see the correctness of his views again to his 'way of thinking', 'peculiarity of thought' and inconsistency of 'judgment'.[196] He even described Tait's views as 'fictions, pure and absolute'.[197]

Neither Spencer nor Tait were prepared to stand down and became bogged down in their own respective trenches, repeating the same arguments again and again, but, consequently, attacking each other's character ever more ferociously. Tait, recognising the quagmire in which he had become trapped, finally thought it time on the 9th of December 1880

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193 Ibid. 800.
194 Ibid. 801.
195 Tait, 'Prof. Tait on the Formula of Evolution', *Nature* 23 (25 November 1880) 80-82, 80-81.
196 Herbert Spencer, 'Mr. Spencer and Prof. Tait', *Nature* 23 (2 December 1880) 100-102, 100-101.
197 Spencer, 'Mr. Spencer and Prof. Tait', 101.

that the hostilities should cease, but not without trying a final offensive. He repeated his disdain of Spencer placing his own formula of evolution on par with Newton and 'alongside of the Law of Gravitation' and attributed this to Spencer being one of the 'metaphysicians' who, in their imaginative 'fancy' uttered nothing but 'nonsense'.[198] Spencer's final reply was focused solely on Tait's treatment of him, which he found unfair, because Tait attributed statements to him that he never made.[199] The discussion was not resumed afterwards, as the positions and reciprocal animosity had become quite clear.

Let us take a step back and look at what was discussed between Tait and Spencer, and in which terms. First of all, as in the previous discussions between Tyndall and Tait, the legitimacy of *a priori* reasoning and the use of the imagination were at stake. Spencer held that experimental and inductive science could only proceed from principles that needed to be established *a priori*. Tait maintained the opposite point and argued that physical truths could only be established by induction and experiment. Secondly, the role of mathematics was discussed: both Tait and the anonymous reviewer accused Spencer of being 'unmathematical', while Spencer rebutted that mathematicians generally lacked the ability to see the bigger picture. Thirdly, as the debate escalated further, both Tait and Spencer resorted more and more to attacks on each other's character. Terms such as 'mental peculiarities', 'habits of laziness', 'lack of judgment', and 'desire to know where knowledge is not' recurred often: both Tait and Spencer recognised that in order to criticise each other's methodological orientations – *a priori* versus inductive reasoning – , they needed to attack the character of the *a priori* philosopher or the inductive experimentalist. The controversy not only revolved around the question of whether Spencer was correct in stating that there was an *a priori* element in Newton's *Principia*, but also around what such an argument said about the character of the man wielding it. In

198 Peter Guthrie Tait, 'Prof. Tait and Mr. H. Spencer', *Nature* 23 (9 December 1880) 123.

199 Herbert Spencer, 'Mr. Spencer and Prof. Tait', *Nature* 9 (16 December 1880) 144.

these discussions, the imagination took centre stage: was the imaginative genius the motive force of science, or was it the inductive experimentalist? Finally, as in the other cases I have discussed in this chapter, the quarrel between Spencer, Tait and others shows how debates on what good science was, which virtues should be employed and what vices should be shunned, were fought out via *personae*, models of scientific selfhood. For Tait, as we have seen earlier, Newton was shorthand for inductive science and inductive virtues. Spencer, however, appropriated the Newtonian image for his *a priori* metaphysical ends, thus angering not only Tait, but also many others in the pages of *Nature* and the *British Quarterly Review*. The accusation that Spencer placed his formula of evolution on par with the grand Newtonian laws of gravity, therefore, should not be overlooked: it was the virtuous mantle of Newton that was at stake in this debate.

Conclusion: mapmaking and the imagination

This chapter has zoomed in on four controversies in which ideals of scholarly selfhood were at stake.[200] In these debates and personal quarrels, Victorian scholar negotiated and demarcated their ideals of what it took to be a scholar. Although the four controversies that I discussed took place over three decades and concerned different parties and debates, I can offer three general concluding remarks about the language of virtue and vice, *personae*, and the imagination in late Victorian science, respectively.

200 These four are of course not the only debates in which Tait was engaged, nor have I explored every theme in every discussion exhaustively. There was, for example, a very visible discussion between Tait and Tyndall in *Nature* on the work of J.D. Forbes, Tait's predecessor at Edinburgh, which I have not discussed (Melinda Baldwin has, in her *Making Nature*, pages 41-43), nor have I discussed Tait's incidental clashes with vector analysts Olivier Heaviside and Josiah Willard Gibbs over the merits of the quaternion method. Chris Pritchard and Michael J. Crowe have discussed this: Crowe, *History of Vector Analysis*, esp. chapters 5 and 6; and Pritchard, 'Tendril of the Hop and Tendril of the Vine: Peter Guthrie Tait and the Promotion of Quaternions, Part I', and 'Flaming Swords and Hermaphrodite Monsters: Peter Guthrie Tait and the Promotion of Quaternions, Part II'.

Let me start with the language of virtue and vice. The four controversies show that debates about proper scientific methodology and debates about disciplinary boundaries were also fought out at a very personal level. This is no surprise for historians of science, but since virtue language is often read as a way of creating unity within particular disciplines or communities, it is worth stressing that virtue and vice were also a sign of discontent.[201] There were generally two contexts in which language of virtue and vice was employed. First of all, there was the polemical context: Spencer accused Tait of 'defects of judgment', Tait accused Spencer of 'laziness', Tyndall accused Thomson of 'unoriginality' and 'dishonesty', and so on. Accusations of vice were thus uttered frequently at opponents in a scientific controversy, as a means to discredit the views of one's adversary. I will return to this kind of vice charge in the next chapter.

As I have stated in the introduction to this chapter, there was also a second, more complex context in which accusations of vice and attributions of virtue functioned: they served to fight out debates about what it took to pursue physical knowledge in late Victorian Britain. The language of virtue and vice offered a common tongue for speaking about matters of scholarly selfhood, and differences of opinion about what a good scholar looked like were therefore fought out in this common tongue. The quarrels between Tait and Tyndall focused not only on what counted as decent scientific evidence (the discussion regarding the merits of Joule and Mayer), or whether men of science could grasp the essence and origin of matter (Tyndall's lecture), but also on what type of scholar should be cultivated. Tyndall clearly cherished a constellation of genius, ingenuity, courage and originality, virtues he opposed to Tait's vices of fear-inspired restraint, caution or Joule's careful experimentation. The same can be said for the dispute between Ingleby and Tait: not only were the relative merits

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201 This point has been made by Herman Paul, who has argued that language of virtue and vice not only served to strengthen bonds between scholars, but that it was also meant to stress difference; virtues were often employed as a declaration of war, or as a defence of a position under pressure: Paul, 'Weber, Wöhler, and Waitz'.

of metaphysics and mathematics discussed, but also the personal traits of mathematicians and metaphysicians. Leibniz's vice of dishonesty is a case in point, as is the 'evidence to character' to which Ingleby referred. Finally, Spencer and Tait discussed not only the importance of *a priori* reasoning as opposed to inductive experimentation, but also questions of scientific selfhood and the mental peculiarities of both Tait and Spencer. Debates over what it took to be a good scholar, therefore, were fought out through the attribution of virtues and the accusation of vice.

This brings me to my second remark, which deals with the relation between the language of virtue and vice, and models for living a scientific life. None of the discussions above were about singular virtues or vices, but rather about a balanced constellation of them. We have seen this emphasis on balance in earlier chapters too: writers of scholarly obituaries taught that a skewed moral balance would lead to vices. When Tait and Tyndall discussed Joule and Mayer, they did not speak about the importance of laboriousness or accuracy or ingenuity in their own right, but rather disputed the relative importance of these virtues for the ideal make-up of the scientific man. In Tyndall's ideal configuration, or Spencer's for that matter, ingenuity and courage were more important than carefulness and laboriousness. Tait, on the other hand, prioritised caution, discipline and restraint over a freer use of the imagination. They each promoted different constellations of virtues, because they held different views of what science was. Tait, being committed to a tradition of natural theology, stressed restraint, while Spencer, committed to scientific naturalism and his own metaphysical system, stressed intuition and creativity.

These constellations of virtues were often inscribed on past scientific heroes, like Newton, Faraday, or Leibniz. Such names functioned as shorthand for a specific way of doing science. 'Newton', at least in Tait's perception of him, stood for a constellation of virtues that enabled an inductive methodology and disciplined the imagination. The appropriation of such *personae* was not unproblematic, however. Tyndall's romantic and imaginative perception of 'Faraday', for example, was at odds with other interpretations of 'Faraday' that cherished the more methodical side of his character. Also, the discussions between Tait and Ingleby, and Spencer and Tait both show that ideal versions of 'Newton' or 'Leibniz' were not always readily accepted. The images of these *personae* needed to be negotiated and their boundaries required policing. This is why the discussion between Spencer and Tait was so fierce: both claimed 'Newton' as their hero. Was Newton an example of an *a priori* metaphysician, as Spencer presented him? Or was he the virtuous symbol of induction, as Tait would have preferred? These shorthand classifications for what it took to be a scholar in late Victorian Britain therefore required continuous boundary work. To frame one type of scientific selfhood as ideal-typical, another type often needed to be presented as an enemy of scientific progress. Accusations of vice and attribution of virtue therefore demarcated and policed the boundaries of scholarly *personae*.

Herman Paul has described this process of boundary work between different scientific *personae* as a process of map-making, a metaphor which fits the findings of this chapter quite well: 'Newton' was a coordinate on an imaginary map of the discipline, just like 'Bacon' or 'Leibniz'. Because these names referred to real historical individuals, there was some consensus about the make-up of these *personae* (Newton, for example, generally referred to a combination of Baconian methodology and imaginative genius), but at the same time, some leeway for reinterpretation was left. Tait's 'Newton', a constellation in which the imagination was disciplined by Baconian virtues of induction, was not the same as Spencer's 'Newton', which cherished ingenuity over these inductive virtues. Moreover, associating a scholar with such a *persona*, e.g. associating Tyndall with 'Mayer' or Ingleby with 'Leibniz', was a strategy of attributing vice to someone. Through association with the spurious 'Leibniz', who in the eyes of Tait stood for dishonesty, arrogance and pride, Tait accused Ingleby of the very same vices. The language of virtue and vice in Tait's four quarrels was thus indicative of a broader disagreement on what good science was, which models of scientific selfhood should be emulated and what the exact content of these models was. Moreover, accusation of vice and attribution of virtue were effective strategies in the process of map-making, as they drew and shifted boundaries between different coordinates on the imaginary map of science.

Finally, this chapter has something to say about the imagination in Victorian science, as it was central to all discussions I have analysed. First of all, a certain measure of imagination was recognised by all parties as being necessary for the pursuit of knowledge. However, what was disputed was the scope of the role the imagination should be allowed to play. Tait did not dismiss the power of the imagination, but expressed that science could only progress if the inductive and Baconian method was primary in science. Like 'Newton', men of science should discipline their imagination through careful, accurate, patient and modest science. Tyndall, Ingleby and Spencer attributed great role to the imagination. Like Mayer, Tyndall's 'Faraday' or Spencer's 'Newton', men of science should enable the imagination to ensure scientific progress. The discussions therefore were not about *whether* the imagination had a role to play in science, but about *which* role the imagination should play. Because everyone was endowed with the faculty of the imagination, moreover, the discussion centred on constellations of virtues that either disciplined or enabled the imagination. Again, balance was the key point here. As such, Tait's controversies echo the themes in academic memory culture: the use of the imagination was not a problem in itself, but an enthusiastic and undisciplined use of this faculty was.

However, historiographical accounts have provided a narrative of disappearance of the imagination in science, in which the faculty became increasingly feared, and even loathed during the nineteenth century because it threatened ideals of communicability and objectivity in science. I have argued that historiography generally tells a tale of disappearance: Lorraine Daston, Richard Yeo and Rebekah Higgitt, all claim that the late nineteenth century saw a new consensus about genius and method and hence the role of the imagination in science. This consensus was very much shaped by the increasing importance of the ideal of objectivity in science: the scientific but subjective self needed to be disciplined in order to arrive at objective knowledge and hard accountable facts. Debates about moral character, these authors claim, slowly became debates about objective methodology, and the interest in the moral make-up of the scholar waned.[202]

This chapter shows that although ideals of objectivity certainly play a major role in the discussions I have analysed, the imagination did not disappear from discussions about scholarly selfhood, and the interest in the moral character of Victorian scholar was still very much alive. Tait explicitly called for the performance of inductive virtues of patience, carefulness, modesty, laboriousness and accuracy to discipline the subjective imagination. In this sense, the Tait case certainly ties in with the historiographical accounts of disciplining the imagination and Tait's accusations of vice can be understood in this light. Tyndall, however, tried to counter subjectivity as well, not through virtues of restraint, but rather through an attack on natural theology and religious prejudice in science, an attack that required the assistance of creative imagination. This suggests that there were multiple threats to the ideal of objectivity: not only sources within the self, like the faculty of imagination, but also sources outside the self, like religious prejudice. The imagination, then, was a human faculty that could lead to vices if deployed wrongly, but which could also be used for virtuous causes. The vices associated with the imagination, therefore, were *relative*, in the sense that some parties considered traits of restraint to be virtuous, while others saw them as vices, depending on their perception of what science ought to be.

In this chapter, I have shown how the language of vice was employed to perform moral boundary work between ideals of science and the models of scientific selfhood that accompanied those ideals. I have focused mostly

202 Daston, 'Fear and Loathing', 86-87. Higgitt, *Recreating Newton*, 184, 191-192; Yeo is more nuanced, and argues that moral and intellectual virtues were uncoupled by the end of the nineteenth century: Yeo, 'Images of Newton', 278-279.

on physics: an academic discipline with career-paths, professorships, journals and other institutions well in place. Although there was a deep disagreement about the aims, methods, ideals and futures of physics, proponents of all parties had access to professorial chairs, laboratories and outlets for their views. Physics, despite internal differences, was an established discipline in late nineteenth-century Britain. The institutional embeddedness of physics translated into a focus on moral boundary work: the boundaries of the discipline had to be constantly policed to keep inappropriate characters, ideals and methods at bay. This caused the debates about virtue and vice to focus primarily on so-called epistemic vices: vices that impeded the acquisition of good knowledge had to be ousted from the disciplinary space of physics. The debate thus focused more on boundary work than it focused on cooperation. In the following chapter, however, I will scrutinise how scholarly cooperation in a decidedly unstructured institutional environment (Shakespearean scholarship) gave rise to wholly different debates about the category of vice. In these debates over scholarly cooperation, it were not epistemic vices in the strong reading of that word that were at stake, but rather, social vices.