Negotiating Notation:
Chemical Symbols and British Society, 1831–1835

TIMOTHY L. ALBORN
Department of the History of Science, Science Center 235, Harvard University, Cambridge, Massachusetts 02138 U.S.A.

Received 30 April 1989

Summary
One of the central debates among British chemists during the 1830s concerned the use of symbols to represent elements and compounds. Chemists such as Edward Turner, who desired to use symbolic notation mainly for practical reasons, eventually succeeded in fending off metaphysical objections to their approach. These objections were voiced both by the philosopher William Whewell, who wished to subordinate the chemists' practical aims to the rigid standard of algebra, and by John Dalton, whose hidebound opposition to abbreviated notation symbolized the suspicion with which older British chemists perceived continental innovations. It is argued that the success of chemists like Turner in this debate reflects their larger success in the 1830s in achieving disciplinary autonomy and in beginning to align themselves more closely with prevailing chemical practice across the Channel.

Contents
1. Introduction .......................................................... 438
2. The lines are drawn: Dalton, Berzelius, and Whewell .......... 440
3. Good, bad, and mostly undecided: the chemists respond .... 446
4. Practice prevails: the disarming of philosophy ............... 453
5. A committee to the rescue: an ad hoc resolution in the BAAS .... 457

I must confess, that the language of symbols is to me
A Babylonish dialect
Which learned chemists much affect;
It is a party-coloured dress
Of patch'd and piebald languages:
T is English cut on Greek and Latin,
Like fustian heretofore on satin.

Richard Phillips (1834)

...the question undoubtedly is, or soon will be, not whether or no we shall employ notation in chemistry, but whether we shall use a bad and incongruous, or a consistent and regular notation.

William Whewell (1831)

1. Introduction

One of the central debates in British chemistry during the 1830s concerned the use of chemical symbols to represent elements and compounds. The main participants in the controversy waged battle in the halls of the Royal Institution and the pages of the Philosophical Magazine, and utilized the newly-founded British Association for the Advancement of Science (BAAS) to negotiate a truce. The debate and its resolution conveyed important professional and methodological messages addressing the proper place of symbols in science, the role of theory and calculation in chemistry, and chemistry's status relative to other disciplines. By 1834, when an ad hoc committee in the chemistry and mineralogy section of the BAAS was formed to discuss 'the adoption of a uniform set of Chemical Symbols', three competing systems had emerged from the contemporary journals and textbooks—each of which claimed powerful support from within the British scientific community. John Dalton, the doyen of the British chemistry community and a well-respected BAAS figurehead, firmly maintained his original system of pictorial or hieroglyphic representation against newer continental competitors such as Berzelius. Self-defined 'practical' chemists such as Thomas Graham and John Prideaux, who avidly defended the Berzelian system, received cautious support from Edward Turner and James F. W. Johnston. Finally, Whewell, an outsider to chemistry but very influential in the BAAS (and also among some chemists), argued for a more rigorous algebraic notation in contrast to Berzelius's shorthand version. The BAAS committee, which included advocates of all three systems, reached a majority decision—fiercely resisted by Dalton and sullenly tolerated by Whewell—in favour of a modified Berzelian approach.  

It is the purpose of this article to sort out how such a consensus evolved and was reinforced in the course of the debate and to suggest disciplinary, generational, and national factors which may have affected its formation. Broadly speaking, these factors reflected the three different forms of authority which were variously asserted and challenged during the controversy. Disciplinary authority was at stake in the fundamental issues raised by Whewell involving the application of mathematics to chemistry. His insistence on strictly subordinating symbols to algebraic formalism aided his attempted propagation of broader methodological goals, which placed chemistry relatively low on his scale of the sciences. Generational authority, personified by Dalton, demanded a delicate critical response from Whewell and the Berzelian sympathizers alike: in the words of Arnold Thackray, Dalton's presence in the controversy produced 'a combination of personal deference and professional unease'. Finally, the national authority of British chemistry in competition with the German and Swedish schools became an issue during the debate, in which lines were drawn  


4 A. Thackray (footnote 3), p. 117.
according to the relative extent to which its participants were willing to adopt the continental Berzelian system. Dalton’s almost xenophobic reaction to foreign chemistry and Whewell’s more complex assertion of national scientific superiority conflicted with the eagerness displayed by most younger practising chemists to use continental progress as a model for reform.

Personal, institutional, and social factors played a primary role in the negotiation of these three forms of authority. Regarding disciplinary authority, for instance, Whewell’s towering position as mineralogy professor at Cambridge strengthened his case for algebraic notation. Regardless of their actual tolerance of Whewell’s prescriptions, none of the chemists who favoured some form of notation could deny the importance of having him on their side. His location in the heart of the ‘Cambridge network’, however, carried variable weight depending on the audience. On the one hand, his close friendship with Michael Faraday assured him a warm reception at the Royal Institution, while his mutually beneficial professional relationship with Johnston and Turner produced a critical respect. On the other hand, Whewell’s affiliation with Cambridge may have led to the much more sceptical (and occasionally hostile) response to his ideas among provincial chemists such as Prideaux. In general, his influence did not penetrate very far into the wider community of British chemists, most of whom leaned toward the provincial camp if not falling squarely in it.

Generational factors, by their very nature, introduced a strong personal and social element into the debate, but also emphasized institutional differences. Generational allegiance was especially strong among chemists who, like Dalton, operated outside the university setting. Older chemists like Richard Phillips at the London Hospital retained a strong fraternal attachment to the older system and to the naive atomic realism on which it was based. Most university chemists, in contrast, continued to hold Dalton in esteem without bothering to let his outdated views on notation affect their work. Since the latter group made up the bulk of the BAAS committee on notation, Dalton was therefore given ample space for dissent in the debate’s official resolution but relatively little actual notice as it ran its course. Finally, institutional and social factors played a major role in the issue of national authority and chemical notation. Whewell’s opposition to the Berzelian system, besides being motivated by methodological considerations, also reflected his active role in the ‘Decline of Science’ debate against Charles Babbage and David Brewster. In that controversy Whewell felt called upon to defend the honour of science at Cambridge and Oxford—and by extension, England in general—against the charge that it had fallen dormant compared to rapid advances made on the continent. London chemists like Turner and Johnston, in contrast, had little reason either to doubt the declinists’ charge or to defend Oxbridge science.

The British debate on chemical notation is below roughly (and somewhat arbitrarily) divided into four stages. The first stage spans the initial expressions of the three systems of notation which were debated between 1831 and 1836: Dalton’s


6 On Whewell’s professional ties to Turner and Johnston, see e.g. his letter to William Vernon Harcourt, 1 September 1831, in Isaac Todhunter, William Whewell, 2 vols (London, 1876), ii, p. 128, where he recommends Turner ‘as eminently well informed and candid’. Whewell later suggested that Johnston be selected to deliver the address to the BAAS on the progress of chemistry and mineralogy.
pictorial system in 1803, Berzelius's symbols in 1813, and Whewell's Royal Institution paper on algebraic notation in 1831. The second stage covers three different responses to Whewell's paper in the two years following its publication: positive, by Royal Institution chemists Faraday and William Brande; negative, by the British Berzelian Prideaux; and ambivalent, by Turner and Johnston in 1833. Whewell's attempt at the end of that year to distance himself further from Berzelius and his more problematic attempt to claim Turner and Johnston as allies completed this stage of the controversy. In the penultimate stage Dalton's ally Richard Phillips entered the fray and Whewell's predominant concern for philosophical issues faded into the background, as the practical advantages of notation became the central disputed issue. An examination of how systems of notation were actually used by Prideaux, Graham and Turner in this period reveals the extent to which chemical practice came to shape the discussion as it approached its conclusion. Finally, the circumstances surrounding the formation, meeting, and final report of the BAAS committee on notation will be discussed. By the time the committee met, I will argue, most British chemists had largely come to ignore Dalton's objections to symbolic notation, and they had refashioned Whewell's philosophical criticisms of the Berzelian shorthand into a form more suitable to their practical needs. The fact that these developments were accompanied with deference to Dalton's reputation as a theorist and to Whewell's stature as a philosopher and scientist did not deter from their practical significance. The committee report, which strongly favoured a modified Berzelian system but allowed ample response from the two dissenting positions, reflected the tendency of British chemists in the 1830s to respect the authority of both tradition and mathematics, but in the end to follow their own course of action.

2. The lines are drawn: Dalton, Berzelius, and Whewell

The three different positions which were argued in the British debate over chemical notation in the 1830s gradually took shape over the three preceding decades. The earliest to be proposed was Dalton's, which he developed in tandem with his atomic theory in the first decade of the nineteenth century. Berzelius offered a new version of symbols to the scientific world in 1813, which he modified somewhat by the time it became a topic of debate in England. Finally Whewell entered the controversy in 1831, when he discovered that chemical notation offered a convenient application of his new ideas on the philosophy of induction to a specific scientific discipline. Following a brief survey of the first two systems of notation, which have been adequately described in Maurice Crosland's *Historical Studies in the Language of Chemistry*, Whewell's paper on notation will be discussed in depth.

In his original paper on the atomic theory in 1803, as well as his *New System of Chemical Philosophy* (1808), Dalton used pictorial symbols to illustrate his view of the structure of matter. He borrowed the use of pictures (instead of letters) to represent chemical elements from alchemy, with the important distinction that he meant each individual picture to represent specific quantities of atoms. Further, he placed symbols next to each other in an order which he took to be the actual spatial arrangement of the atom in a molecule: carbonic acid, for instance, in which two oxygen atoms were repelled by a central carbon atom, was denoted by \( \text{O} \text{●} \text{O} \). Thomas Thomson first published Dalton's symbols in the third edition of his *System of Chemistry*, and the following year Dalton himself presented a table of them in his *New System*. Despite the typographical problem which pictorial symbols presented, Dalton and Thomson continued to support their use through the 1820s. Even Edward Turner, who would
later adopt a cross between Whewell’s and Berzelius’s systems, used Dalton’s symbols in the 1825 edition of his *Elements*. The most common justification for the continued use of pictorial symbols, despite the prevailing practice of following Berzelian notation on the continent, was its advantage in displaying the spatial configuration of compounds.7 This argument reflected a more central faith on the part of Dalton and his immediate followers that his atomic theory represented physical reality, and not merely a convenient device for calculating equivalent weights. It also betrayed a lingering suspicion among many older British chemists against continental innovation. Even Thomson, for instance, who ultimately abandoned pictorial systems and sided with Babbage and Brewster in the ‘decline of science’ debate, remarked in the preface to the seventh edition of his *System of Chemistry* (1831) that continental attempts ‘to introduce a new Chemical nomenclature... are all quite unsuitable to the idiom of our language’.8

Berzelius introduced his version of chemical notation in 1813, in an article on azote published in Thomson’s *Annals of Philosophy*. In the article he shared Dalton’s quantitative approach to both chemistry and symbolism, but parted from the Manchester chemist by representing atoms with letters. Although modified several times, his system’s most salient features included the combining of symbols in the form A\(^{B}\), and the representation of oxygen by dots over the symbol of the base. His new symbols, he claimed, were ‘destined solely to facilitate the expression of chemical proportions, and to enable us to indicate, without long paraphrases, the relative number of volumes of the different constituents contained in each compound body’. In contrast to the theoretical goals implicit in Dalton’s presentation of symbols, Berzelius mainly developed his as a matter of convenience. Further, his refusal to accept the physical reality of the atomic theory severely diminished his interest in the spatial advantages of Dalton’s system. Both these factors aided in the acceptance of Berzelian notation on the continent in the 1820s and in England by 1835.9

Whewell originally took an interest in chemical notation in 1829, shortly after accepting the mineralogy post at Cambridge. In July of that year he wrote to John Herschel asking for a copy of an article containing Berzelius’s ‘views on the new chemical system and new chemical nomenclature which modern discoveries had suggested’. His penchant for synthesis led him to suggest the inherent utility of linking his field with chemistry by means of a common notation: ‘I am more and more convinced that chemistry and mineralogy, which have been coquetting together so long, should be indissolubly married in order to ensure the happiness and dignity of both parties...’10 Even in 1829, though, his language—and in particular, his reference to the ‘dignity’ which would result from a unified set of symbols—belied an interest in notation which transcended its potential utility. Already, Whewell was beginning to think in terms of the relative place which traditionally classificatory sciences like

7 M. Crosland (footnote 3), pp. 256–64.
9 Jacob Berzelius, ‘Essay on the Cause of Chemical Proportions, and on some Circumstances relating to them: together with a short and easy Method of expressing them’, *Annals of Philosophy*, 3 (1814), 43–52 (p. 51).
10 M. Crosland (footnote 3), pp. 270–8. The acceptance of Berzelian notation on the continent is indicated by the list of German textbooks using his symbols provided by Bettina Hauß, *Deutschsprachige Chemielehrbucher 1775–1850* (Stuttgart, 1987), p. 289.
11 William Whewell to Herschel, 15 February 1829, in J. Todhunter (footnote 6), ii, p. 98.
chemistry might occupy in a hierarchical system of science, and how they might make progress toward such a system's more 'dignified' mathematical regions. Two years later, in 1831, he first hinted about the nature of his proposed hierarchy, offering his paper on chemical notation as an example of how it could be applied in practice. Six years after that, in his History of the Inductive Sciences (1837), he revealed the hierarchy in all its glory.

In 1831 Whewell was still grappling with the problem of how best to present his nascent philosophy of science to the reading public. Original publications, such as the notation paper and a similar effort (written in 1829) to express the laws of political economy in algebraic form, offered just one option. He also advanced his views informally, through a wide correspondence with influential scientists like Faraday and Charles Lyell, and indirectly, through several review articles in the British Critic and the Quarterly Review—most notably his notice of Herschel's Preliminary Discourse in 1831. Combining the zeal of a missionary with the strategy of a general, Whewell brought all these options into play in an attempt to convert potential allies over to his view of induction. Writing in February 1831 to his friend Richard Jones, a London economist who was considering a work on induction in the social sciences, he confided:

I shall be glad to see your speculations on induction... for among other questions it is certainly an important one how the true faith can best be propagated. I have done what I could in my review of Herschel. I do not know whether you looked at it in that view, but I intended it to be as good an attempt as I could make to get the people into a right way of thinking about induction. ... I do not believe the principles of induction can be either taught or learnt without many examples.¹¹

One of Whewell's favourite methods of teaching induction by example, especially among descriptive scientists, was by discussing nomenclature. He filled much of his correspondence in the early 1830s with suggestions and strictures regarding the proper role of language in the classificatory sciences. Permeating these efforts was the theme that sciences such as chemistry, geology and natural history were incapable of describing nature in any exact sense and, therefore, needed to be reduced to the ultimate linguistic precision of mathematics. In 1831, for instance, he warned Lyell against confusing geological terms with exact definitions: 'in natural history sciences it is... impossible to have words which are such definitions. What you want words for is to classify.'¹²

Whewell also criticized claims to certainty in the classificatory sciences, a stance which provoked his only major disagreement with Herschel's Preliminary Discourse. In that work, Herschel had sided with the Scottish philosopher Dugald Stewart in discounting the epistemological priority of nomenclature, which he called 'more a consequence than a cause of extended knowledge.' Classification, on the other hand, he viewed as capable of spurring scientific advance, since it was closely concerned with nature. Herschel thereby implicitly endorsed an increased epistemological status for classificatory sciences, while stripping the deductive sciences of any claim to absolute certainty. With deference befitting a good friend, Whewell mentioned this endorsement with raised eyebrows in his review of Herschel: 'perhaps he has too much restricted his view to [nomenclature's] use as shown in the process of classification, and the sciences

¹¹ Whewell to Richard Jones, February 1831, in ibid., ii, pp. 115–16.
of which this is the main ingredient... the effects of a well chosen nomenclature, or, at least, of a distinct terminology, extended as fully to the expression of laws as to the recognition of objects."13

Although Whewell's review did not specifically identify such a 'distinct terminology' as mathematical or algebraic, the other examples of proper induction which he published at the same time leave little doubt that he had that sort of language in mind. In March 1829 he read a paper to the Cambridge Philosophical Society on the 'Mathematical Exposition of some Doctrines of Political Economy', in which he claimed that 'some parts of this science... may be presented in a more systematic and connected form, and I would add, more simply and clearly, by the use of mathematical language than without such help.'14 The themes of consistency and clarity reappeared two years later in his paper criticizing Berzelian notation, in which Whewell presented an integral part of his personal programme to spread the 'true faith' of induction. The chemists who responded to it composed an influential segment of 'the people' whom he desired to convert and their acceptance or rejection of his system of notation supplied a telling barometer of the success of his conversion efforts.

In addition to disputing Berzelius's system on methodological grounds, Whewell had patriotic motives for opposing the Swedish chemist's position. His Royal Institution paper coincided with a heated debate over the status of British science, originally spurred by the publication of Charles Babbage's Reflections on the Decline of Science in England (1830). Although Babbage's criticism indicated British science in general, the specific target of his book was the system of scientific education at Oxford and Cambridge, which he accused of being apathetic and unproductive. Whewell immediately rose in response: in a review article purportedly on the Transactions of the Cambridge Philosophical Society, he provided a defensively exhaustive list of the accomplishments of Oxbridge men of science. An example of the tone of the piece is his mention of the Cambridge chemist James Cumming, whose important discoveries in electrochemistry were victims of 'an unacknowledged appropriation' at the hands of the French savant Becquerel.15 Berzelius, whom Whewell acknowledged to be both more prominent and less culpable than Becquerel, proved more problematic to his defence of British science. As a result, although he still challenged the overwhelming authority of Berzelius, his criticisms in 1831 tended to be deferential in tone and generously interspersed with compliments. The need for diplomacy, however, did not completely hide his suspicion and insecurity towards continental scientific progress.

By the time Whewell entered the notation controversy in 1831, he at least was convinced that the real debate was no longer between Dalton's 'usual language of

13 John F. W. Herschel, A Preliminary Discourse on the Study of Natural Philosophy (London, 1830; reprinted Chicago, 1987), pp. 135-8; see also Herschel, 'Whewell on the Inductive Sciences', in Essays (London, 1857), p. 172; Whewell, 'Modern Science—Inductive Philosophy', Quarterly Review, 45 (1831), 374–407 (p. 391). Although W. H. Brock (footnote 3, p. 41) refers to a 'Herschel—Whewell algebraic system' of chemical notation, the extent to which this label applies to the events of the 1830s is not clear. Herschel only publicly advocated the application of algebra to chemistry in 1819, when he was still trying to reform the mathematics curriculum at Cambridge, and in 1858, by which time his relative interest in inductive philosophy had waned. He makes no reference to chemical notation in the Preliminary Discourse.


chemistry' and the language of symbols, but rather between different opinions concerning what the aims of the latter language should be. He therefore devoted only a few opening remarks to the pitfalls of the 'usual language', saving the brunt of his attack for Berzelius. He contrasted the advantage of brevity, which had been Berzelius's chief motivation for the introduction of chemical symbols, with the principles of clarity and consistency, on which he claimed to base his own system of notation. As this difference specifically applied to the symbols themselves, he proposed the forms \( nA + nB \) for compounds and \( O \) for oxygen, compared to the Berzelian symbol \( \text{A}^\circ \text{B}^\circ \) for compounds and dots above oxygenated elements. Judging from the response which his paper generated, Whewell was successful in his attempt to shift the main focus of the debate from whether to adopt symbols to what system should be adopted. Although all of the immediate replies to his article offered at least partial disagreement with his specific proposals, none of them questioned his defence of notation.

Whewell had not resigned from his chair in mineralogy in 1831, but he was increasingly dividing his time between scientific and philosophical pursuits. Both his practical concerns as a mineralogist and his methodological concerns as a fledgling philosopher of science were therefore manifest in the Royal Institution paper. As Berzelius had done in 1814, Whewell argued that the adoption of symbols was practically necessary for the progress of both chemistry and mineralogy: 'I have no hesitation in saying', he wrote, 'that in mineralogy it is utterly impossible to express clearly, or to reason upon, the chemical constitution of our substances, without the employment of some notation or other.' On most practical questions regarding notation, in fact, he tended to follow Berzelius's example. He adopted the same Latin abbreviations, with the identical motive of facilitating international scientific discourse. Similarly, he generally grouped the elements into compounds according to Berzelian rules of simplicity in chemical combination—with the important difference that he stressed the inherently arbitrary nature of such combinations.

Whewell's presentation of clear reasoning as a practical consideration belied his more fundamental philosophical concerns and marked the point at which he decisively parted ways with Berzelius. In language tinged with nationalist hygiene, he faulted the continental system on two counts: for being inconsistent with the laws of algebra and for concealing the theoretical basis of what it presented. The charge of inconsistency, as well as the hint of nationalism, was clear from his purported aim in the Royal Institution paper: to 'remove the gross anomalies and defects with which the foreign notation is disfigured, and to reduce it, with as little change as possible, to mathematical symmetry and consistency'. He levelled his second charge with similar force in the paper's conclusion: 'One method [Berzelius's], by a misapplication of mathematical symbols, gives us a sign which can only record an opinion possibly false: the other [Whewell's] represents simply what is certainly true, and enables us to reason from the fact to all its possible inferences, without considering anything except the notation itself.'

Of Whewell's two charges against Berzelius, that of inconsistency to algebraic laws was the less serious. Whewell himself was occasionally willing to sacrifice consistency in

---

17 Ibid., p. 437. Although Berzelius shared Whewell's positivism regarding molecular constitution, he did not attempt to subordinate hypothetical combinations under more 'certain' mathematical laws. As far as Whewell's philosophy of science was concerned, therefore, Berzelius and his followers were practically as guilty of asserting the 'reality' of their hypotheses as were naive realists such as Dalton.
18 Ibid., pp. 437, 453.
favour of convention, with the understanding that a 'regular and systematic' symbol for any element be kept distinct from 'an abbreviation, which may be employed for the sake of convenience, and which, I believe, in the case of minerals it will generally be most simple to use'. His willingness to part from his system in the course of actual mineralogical investigations indicated his proximity to Berzelius on practical issues. This tension between practical and philosophical concerns returned to haunt Whewell in later stages of the notation debate, when defenders of Berzelius accused the Cambridge mineralogist of imposing a double standard for consistency. Such a double standard was indeed apparent in the Royal Institution paper, in which he introduced several modifications to Berzelian notation based solely on grounds that it was 'not consistent with algebraical rule'. The most significant of these, since it divided British chemistry for the next five years, was his preference of the additive symbol \( o \) for oxygen rather than the placement of dots over the symbol of the base.\(^{19}\)

When Whewell turned from the notation of oxygen to the representation of several elements in combination, both of his complaints against Berzelius came into play. He contrasted his notation for stilbite, \( 4(S + A) + (3S + C) + 6q \), with the Berzelian version, \( 4AS^3 + CS^3 + 6q \), concluding that the latter 'violates all mathematical consistency, and puts out of sight the identity of different ways of considering the same analysis'. Regarding the first point, he merely had in mind the fact that the combination of chemical elements, which were additive in nature, should be represented by symbols denoting addition rather than multiplication. This relatively simple emphasis on saving the additive appearances in chemical notation, however, was rooted in his more central epistemological claim that chemistry was capable of determining only quantitative values with any amount of certainty. Berzelian notation expressed hypothetical arrangements of elements, the determination of which Whewell considered to be an indefinite, and therefore improper, aim of chemistry. The Berzelian symbol for stilbite, in his opinion, was 'almost entirely useless as an instrument of calculation', since no one could 'see any algebraical reason for supposing it the same with \( 4AS^2 + CS^7 + 6q \), which it undoubtedly is'. Whewell's notation, in contrast, expressed only the relative quantity of elements in a molecule, and allowed every possible combination to be considered with equal credence.\(^{20}\)

When he decried Berzelian symbols as 'useless instruments of calculation', Whewell effectively limited the proper sphere of chemistry to the collection of quantitative data. By subordinating chemical notation to calculation, he hoped in the long run to subordinate chemistry to less qualitative sciences like mechanics. His criticism of the Berzelian system, that it limited chemists to 'one selected and frequently arbitrary view of the body's constitution', reinforced that goal by stressing the need to keep the language of chemistry free from qualitative questions such as molecular structure.\(^{21}\) In 1833, when he addressed the British Association on the proper order of the natural sciences, and again in 1837, when he organized his *History of the Inductive Sciences* along similar hierarchical lines, he placed his isolated criticism of Berzelius in a more explicit philosophical context. The chemists who variously opposed Whewell's system of notation, although not always openly recognizing its wider links with his philosophy, implicitly cast their votes against that 'true faith' which threatened their claim to

\(^{19}\) Ibid., pp. 448-9.

\(^{20}\) Ibid., pp. 439-42.

\(^{21}\) Ibid., p. 439.
disciplinary autonomy. Their negative votes most frequently came in the form of ignoring his advice altogether, or using only those parts of it which did not keep them from going about business as usual.

3. **Good, bad, and mostly undecided: the chemists respond**

The response to Whewell ranged from wholly positive, by Royal Institution members Michael Faraday and William Brande, to severely critical, by John Prideaux. Most chemists, however, sat somewhere in between, combining an honest respect for Whewell’s aims with a refusal to offer complete compliance. Faraday, a long-time friend of Whewell’s, frequently turned to him for advice on questions of electrochemical nomenclature. As secretary of the Royal Institution, he was directly responsible for publishing Whewell’s paper in its journal. Two months before it appeared in print Faraday wrote to Whewell to express complete (but significantly, not public) sympathy with his friend’s views:

> Your remarks upon chemical notation with the variety of systems which have arisen... had almost stirred me up to regret publicly that such hindrances to the progress of science should exist—I cannot help thinking it a most unfortunate thing that men who as experimentalists & philosophers are the most fitted to advance the general cause of science & knowledge should by the promulgation of their own theoretical views under the form of nomenclature... actually retard its progress.

While displaying full agreement, however, Faraday’s letter fell short of fully comprehending Whewell’s position. He concluded his apparently straightforward endorsement of Whewell’s methodology with a comment wholly at odds with the stated intention of the paper on notation: ‘It would not be of so much consequence if it was only theory & hypotheses which [chemists] thus treated but they put facts or the current coin of science into the same limited circulation when they describe them in such a way that the initiated only can read them’. 22 Although clearly not intending to contradict Whewell, Faraday’s comment reversed Whewell’s crucial distinction between fact and theory.

Whewell received fuller comprehension of his position, and more meaningful support, from Brande. As Humphry Davy’s successor at the Royal Institution, and in the tradition of Davy’s epistemology, Brande had been one of the most prominent opponents of Berzelian notation when it had first appeared in 1813. Twenty years later, he again criticized Berzelius, only this time from Whewell’s perspective. At an Institution meeting in early 1833, Brande proposed to 'submit to the consideration of English chemists, and especially of teachers of chemistry, a system of symbolic notation, more consistent with algebraic notation, and not open to the inconveniences and misconstructions which the adoption of Berzelius's system would probably involve'. He contrasted the Berzelian method of representing oxygen with Whewell's 'less objectionable method', and similarly followed Whewell’s other prescriptions as outlined in the paper of 1831. In the fourth edition of his *Manual of Chemistry* (1836), he

---

persisted in his allegiance to Whewell, becoming one of only two chemists in Great Britain who consistently employed Whewell’s symbols in a textbook.23

Despite Faraday’s private encouragement and Brande’s eventual support, the most immediate response to Whewell was negative. John Prideaux, a chemist at the Plymouth Institution, disputed Whewell’s alterations to the Berzelian system in a letter published in the August issue of the Philosophical Magazine. As Whewell had done, Prideaux opened with brief remarks which indicated that the battle over notation in England was still being waged not by two, but by three sides. Conscious of Whewell’s great authority in the British scientific community, and equally conscious that many older British chemists remained opposed to symbols, he expressed pleasure ‘to see Professor Whewell’s eminent name enlisted in [symbols’] advocacy’. He also found little reason to disagree with Whewell’s practical considerations for adopting chemical notation, avowing to ‘concur with all that is… stated [in Whewell’s paper] of the practical convenience and utility of such symbols’. As a devoted follower of Berzelius, he understandably parted ways with Whewell only when forced to choose between convenience and consistency. He opened his assault by criticizing Whewell’s attempts to ‘sacrifice this graphic simplicity [of symbols], in order to convert them into an algebraic notation’.24 A practical chemist, Prideaux lacked either interest or ability to refute Whewell’s more serious philosophical objection that Berzelius had used notation to conceal arbitrary hypotheses and he ignored that argument in his letter.

Prideaux’s reasoning against the charge of inconsistency was straightforward and successful. He competently demolished Whewell’s argument against representing compounds in the form A"B", all the while stressing the practical superiority of the Berzelian system. It took him only two paragraphs to dismiss Whewell’s allegation that Berzelius had absurdly attached multiplicative properties to additive chemical combinations:

[...the] juxta-position K◊, and the employment of an index figure, NH³, as practised by Berzelius, lead the chemist into no error, because their subjects are not susceptible of algebraic powers, or of being multiplied into each other. We can have neither cube nor square of H (hydrogen), nor obtain a multiple of K by ◊…

Although juxta-position implies multiplication in algebra, the signification is arbitrary; and in another science, equally mathematical, with elements susceptible of every mathematical power, we can so place them without fear of understanding CLV as C × L × V, or 534 as 5 × 3 × 4.

Prideaux’s logic cut to the heart of Whewell’s assertion that mathematical statements were necessarily less arbitrary than other forms of language; essentially he was using Herschel’s argument that no system of representation had any natural claim to priority over a collection of observations. He was similarly forceful in his assertion of the practical superiority of the Berzelian system, complaining of the increased length of formulae required by Whewell’s system. In the end, he concluded, brevity should be preferred over consistency: ‘The multiplication of lines and brackets in the proposed notation gives it, in my view, a comparatively perplexed appearance, though

23 M. Crosland (footnote 3), pp. 278–9; Philosophical Magazine, Third series, 2 (1833), 309–11. The other was John F. Daniell, Professor of Chemistry at King’s College London, who sparingly used Whewellian symbols in his Introduction to the Study of Chemical Philosophy (1839). See Bud and Roberts (footnote 3), p. 40.
algebraically just... The chemistry is in fact sunk in the mathematics, simple as they are'.

From the impracticality of the algebraic system, Prideaux turned to the double standard which Whewell employed by proposing his own set of mineralogical abbreviations while condemning Berzelian shorthand. In that case, he claimed, Whewell's notation was 'severally constructed for the occasion, free from the restrictions of any rule of intelligibility'. Although Prideaux did not disapprove of adapting symbols to meet different circumstances, he did correctly accuse Whewell of doing so against his own advice. In a further contribution to the *Philosophical Magazine*, the chemist R. Warrington repeated this criticism against Whewell, in more pointed language: 'Professor Whewell states that these contrivances and contractions are to be considered as mere abbreviations, very convenient, but not indispensably necessary. If not so, why are they introduced?... [T]he strict reason I imagine to be, that from Prof. Whewell's wishing to render the system perfectly mathematical, the different formulæ must necessarily be very extended, and therefore inconvenient'.

The extreme responses of Brande and Prideaux did not represent the opinions of most British chemists, nor in the long run were they very influential on chemical practice. Edward Turner and James Johnston, whose moderate position in the debate more closely reflected the attitudes of many chemists in the 1830s, also wielded more authority among their contemporaries. Without denying the validity of Whewell's philosophical arguments, nor wholly ignoring his proposed system of notation, Turner and Johnston stubbornly refused to follow him in subordinating chemistry to mathematics. Their halfway response to Whewell can be located in their social and educational backgrounds, which placed them firmly between the personal influence of Whewell and the continental tradition then taught in Scotland. Both were transplanted Scots: Turner had received an MD in Edinburgh and lectured there until accepting the chemistry chair at University College London in 1838; while Johnston, who had received his MA at Glasgow under Thomas Thomson before moving to Durham to teach chemistry and mineralogy, went home to Scotland every vacation. Together they forged strong links with many important English chemists, leading Whewell to court their favour with university recommendations and BAAS funds in an effort to win the chemical community over to his side. Despite the perquisites that came with staying in Whewell's good graces, however, Turner and Johnston continued to keep most of their attention directed to developments in Sweden and Germany. Turner had spent time in Göttingen from 1819 to 1821 studying under Stromeyer, where (according to his friend Robert Christison) 'he mastered chemical science, made himself a good algebraist, and became one of the foremost mineral analysts in Europe'. Significantly, the 'good algebra' which Turner learned was from the continental example, not from Whewell. Johnston's continental ties extended to Berzelius himself, under whom he studied from 1830 to 1833 while on leave from Durham.
Chemical notation appeared for the first time in a British chemistry textbook when Turner revised his *Elements* in 1833. The essentially practical nature of Turner's choice to introduce notation is evident from the manner in which it appeared. As he described in his preface to the new edition (the fourth in six years), he only introduced chemical symbols halfway into the book, upon confronting the difficulty of using ordinary language to give an account of Liebig and Wöhler's work on cyanogen. He presented his choice as a fortuitous discovery of the utility which the new notation offered to chemical education, as well as to practising chemists: 'Having once employed them advantageously', he continued, 'I was soon tempted to introduce them again; and this speedily led to the discovery that chemical symbols are not only fitted to be a convenient abbreviation among educated chemists, but may be made a powerful instrument of instruction by teachers of chemistry'. Although Turner's inclusion of notation in his *Elements* may be attributed partly to the expository facility which it offered him, his concluding remarks in the preface indicate that he was not unaware of the wider debate currently brewing over the proper use of chemical symbols. Despite his awareness of the different systems, however, he refused to take a firm position regarding their respective merits. In Whewell's favour, he stressed that the arrangement of symbols be kept 'in strict accordance with the rules of algebra', and generally refused (at least in the fourth edition) to use the Berzelian form A'B'. However, Turner simultaneously followed parts of Berzelius's system which ran directly counter to Whewell's. In the preface, for instance, he proposed—'in common with Berzelius'—to denote oxidation and equivalence respectively by dots and dashes.30

In practice, Turner resolved his apparently contradictory use of Whewell and Berzelius either by limiting each system to its own sphere of utility or by simultaneously presenting both as alternate methods of describing the same compound. He generally reserved the latter technique for his initial definition of a compound, such as his statement that 'the formula of the protoxide [of iron] is Fe + O, or Fe'. When deciding between the two systems, he distinguished between cases involving chemical change, for which he judged Whewell's algebraic notation well-suited, and cases describing composition, for which Berzelian abbreviations were satisfactory.31 His discussion of cyanogen, in which he first used notation, involved the transformation of prussic acid and water into ammonia and formic acid, and therefore justified recourse to algebraic symbols:

\[
\begin{align*}
1 \text{ eq. Prussic Acid; } 3 \text{ eq. Water.} & \quad \| \quad 1 \text{ eq. Ammonia; } 1 \text{ eq. Formic Acid.} \\
(N + 2C) + H & \quad \| \quad N + 3H \quad 2(C + O) + (O + H).
\end{align*}
\]

Turner used Whewell's logic to justify his choice: 'the chemical student will find it instructive practice to study the change by help of a simple algebraic formula... The + signs of the formula indicate combination'. He used similar notation in subsequent sections of the *Elements* in which, as he wrote regarding hydracid salts, elements were 'very prone to arrange themselves in a new order'.32

It is fair to surmise, considering Turner's remarks in his preface, that Whewell's Royal Institution paper had provided the main impetus for his initial decision to use notation. In this sense, Whewell had convinced at least one leading chemist to

---

31 Ibid., p. 509; although Turner codified this arrangement the following year when the *Elements* reached its fifth edition, in 1833 his division was only implicit and not always consistent.
32 Ibid., pp. 399, 692.
introduce his version of notation into England, since Turner not only recognized the philosophical underpinnings which lay beneath Whewell’s notation but even passed them along to his readers. Implicitly, however, Turner limited his support of Whewell’s position to the specific case of chemical change. Although he certainly appreciated the clarity which algebraic notation lent that subject, he was not convinced that a rigid insistence on consistency was best for chemistry. First gradually, then more systematically, his discussion of chemical composition in the Elements came to rely solely on Berzelian symbols for oxidation and equivalence. Fifty pages after first introducing symbols arranged according to Whewell’s system, Turner slipped into Berzelian language in a discussion of the formation of potash:

When the peroxide is put into water, it is resolved into oxygen and potash...[consisting of] 1 equivalent of potassium, and 3 of oxygen. Hence, representing potassium by Po, the formulae for the oxides will be Po + O, and Po + 3O; and if with Berzelius we denote the number of equivalents of oxygen by an equal number of dots placed over the oxidized body, these formulae will become Po, and Po.

As Turner neared the end of the part of his Elements on inorganic chemistry, he started using Berzelian notation to describe the arrangement of elements in a compound and Whewell’s only to describe their rearrangement in a chemical reaction. Regarding compounds of general categories such as sulphates, nitrates or phosphates, for instance, he first described each group of compounds in terms of a Berzelian ‘general formula’ (e.g. R + N for nitrate), then with specific examples.33

Shortly after Turner had published the fourth edition of his Elements, James Johnston’s survey of the ‘Recent Progress and Present State of Chemical Science’ appeared in the second annual British Association Report, which was circulated at the Cambridge meeting in June 1833. Although Johnston had originally delivered the report in Oxford the previous June, the published version underwent ‘considerable alterations’ in order to incorporate Turner’s new findings. Among other things, his report was notable for employing chemical symbols along lines similar to Turner’s, and for its short commentary on the respective merits of the two main competing systems of notation. In terms of his actual use of symbols, Johnston was less consistent than Turner in choosing between algebraic and Berzelian notation, but his method for deciding relied on the same basic rationale. Although he had little cause to describe chemical change, he treated isomorphism analogously as the substitution of one element with another and accordingly employed algebraic symbols when discussing that phenomenon. In most cases, similarly, he resorted to Berzelian dots and dashes when merely describing bases.34

Johnston’s commentary on different systems of notation, while essentially repeating Turner’s moderation with regard to both systems, edged closer to Berzelian notation. After presenting the essentials of the Berzelian system, he proclaimed that it possessed ‘the two great requisites clearness and brevity, and it would be very difficult to devise any other system which should possess them in an equal degree’. He then repeated Whewell’s objection that Berzelius had appropriated a form of notation inconsistent with the additive property of chemical compounds, and agreed that ‘it would certainly

---

33 Ibid., pp. 448, 649-91.
have been very desirable if such an appropriation could have been avoided'. Like Turner, however, Johnston was willing to go only part of the way with Whewell. Whereas Whewell had emphasized clearness and consistency, brevity remained equally important for Johnston. Furthermore, he questioned Whewell's claim that Berzelian symbols were always less clear than algebraic notation: 'It would obviously be to sacrifice both brevity and clearness', he concluded, 'to insert all the algebraic signs in all chemical formulae'.

Despite the clearly selective use to which Turner and Johnston put Whewell's suggestions in 1833, the Cambridge philosopher remained undaunted. Exercising a fair degree of selection himself, Whewell chose to interpret their position on notation as fully agreeing with his own. That year in the British Association and the Philosophical Magazine, he again argued in favour of algebraic notation, prominently citing both chemists in his support. A secretarial address at the Cambridge meeting of the BAAS in June 1833 was followed five months later by a published letter containing further 'Remarks ... respecting the Use of Chemical Formulae'. In both statements Whewell was responding to the critical notice which Berzelius had made of his Royal Institution paper in his annual report to the Swedish Academy in 1832. In the report Berzelius wryly observed the national context of Whewell's remarks:

Some opinions concerning the chemical formulae have been published in English Journals. The learned of that nation, little acquainted with foreign languages, do not acquire till late any knowledge of the progress of science in other countries, and always find excuses in defence of this slowness ... that the thing in questions is foreign, and must be either extremely important, or must have become somewhat old, in order to obtain a more general notice.

He also noticed Whewell's intention 'to purify and improve the foreign system' and realised the connection between that aim and the attempt to strip notation down to 'a simple representation of the results of analysis'. Berzelius was unmoved: he concluded by supporting Prideaux's remarks and insisting that symbols should primarily be used as tools to express the composition of chemical bodies.

Whewell's remarks on notation before the British Association appeared in the context of his opening address on the relative positions of the various scientific disciplines in England and the prospects for their advancement. The address reflected his growing interest in a hierarchical philosophy of science, which he hoped to spread to his captive audience of British Association members in Cambridge. Informing the assembly that 'every labourer in the field of science, however humble, must direct his theories by some theoretical views', he concluded that the leaders of the BAAS 'may perhaps aid them to direct themselves'. As in his review of Herschel, he did not specifically reveal his idea that such direction should be mathematical, but he implied as much in his adjoining presentation of the various sciences which fell under the British Association's umbrella. This part of Whewell's BAAS address was essentially a dry run for his History of the Inductive Sciences, which was not published until 1837 but was fully outlined by 1834, and it may be taken as a fair exposition of his mature philosophy of science. As he would do four years later in his History, he placed

36 Translated and reprinted in Whewell, 'Remarks on a recent Statement by Berzelius respecting the Use of Chemical Formulae', Philosophical Magazine, Third series, 4(1834), 9–10; originally published in the Swedish Academy's Jahresberichte, 12 (1833), 168–70. Whewell italicized the word foreign in his translation.
37 British Association Report (1833), pp. xx, xii; On Whewell's plans for his History see his letter to Richard Jones, 21 August 1834, in Todhunter (footnote 6), ii, pp. 186–8.
chemistry at the same place on the scientific scale as mineralogy, above physiology but below geology. He urged that investigations in chemistry, as in all the sciences in its immediate hierarchical vicinity, receive direction by drawing analogies to more mathematical fields like algebra, astronomy and mechanics. Since chemistry and mineralogy were just entering the stage of useful classification, he continued, its notation must similarly be kept in tow. In such sciences, he concluded, ‘Notation and Nomenclature are questions subordinate to calculation and theory’. Whewell observed that such subordination had already been achieved in crystallography by the Germans, and desired that ‘the Notation of Chemistry also should be so constructed as to answer the same purpose’. At this point he invoked the support of Turner and Johnston, implying with only partial justification that they favoured his own methodologically ‘pure’ system of notation over the Berzelian arrangement: ‘Dr Turner in the last edition of his Chemistry, and Mr. Johnston in his Report, have used a notation which has this advantage, which that commonly employed by the continental Chemists does not possess’.  

Whewell's renewed assault on the continental notation, to which he had devoted only passing attention in his British Association address, was the main focus of his letter to the Philosophical Magazine that autumn. In the letter he provided a translation of Berzelius's remarks to the Swedish Academy and then responded to those remarks. His response emphasized the fundamental split between practical and philosophical concerns which had marked his initial paper, as well as the gap between himself and Berzelius regarding the proper use of notation in chemistry. As before, he found little reason to fault the practical utility of the Berzelian system, but questioned its philosophical merits. In contrasting the two systems, he displayed a perfect understanding of Berzelius's instrumentalist view of symbols, recognizing that the practical-minded Swedish chemist would view his algebraic modifications as 'wanton and superfluous'. Whewell's awareness of that fact, however, did not abate his insistence that such a view must be kept subordinate to the broader demands of his own vision of science:

[Berzelius] views his formulæ merely as modes of expressing his own opinion of certain compositions, briefly and clearly. I consider that chemical formulæ are capable of doing more than this,—of expressing the analysis, without adopting any one's hypothesis of the mode of composition; and of showing how different analyses, and different views of composition, are necessarily related to each other. And this can only be done by using algebraical formulæ constructed according to algebraical rules.

Again, Whewell somewhat disingenuously appealed to Turner for support. In a note, he cited Turner's decision in the fourth edition of the Elements to 'employ chemical symbols in strict accordance with the rules of algebra', without mentioning his simultaneous (and, according to Whewell's logic, contradictory) decision to use Berzelian symbols for oxides.

In his response to Berzelius, Whewell strengthened his claim that the foreign notation was overly restrictive. Referring to the Swedish chemist's shorthand symbol for garnet, Whewell's parting shot similarly lacked any trace of compromise: 'It is easy

to make formulae simple enough, if we want them to mean little... A person who was contented to express somewhat less than Berzelius, might have “discovered” a simpler formula still, and might have denoted garnet by a single letter $g$. But such simplicity would probably not be considered as a merit of a high order. A severe limitation in Whewell’s eyes, however, was precisely the reverse for Berzelius. As Whewell was well aware, Berzelius could not have accepted his algebraic strictures without also accepting the subordinate role which his philosophy of science had delegated to chemistry and mineralogy. Berzelius’s choice to ignore those strictures, as ‘superficial’ from a practical point of view, carried an implicit rejection of the Whewellian hierarchy of science. His ultimate preference of simplicity and convenience over philosophical meaning was bound to keep any productive discourse between the two men at a minimum.

In his Royal Institution paper of 1831, Whewell had indicated practical as well as philosophical advantages relating to the use of chemical notation, displaying some ambivalence concerning which should be preferred. In his address to the British Association and his letter to the Philosophical Magazine two years later, he displayed no such ambivalence: philosophical issues were to take precedence, regardless of the short-term practical sacrifices which this might require chemists and mineralogists to make. During the interim, significantly, Whewell had vacated his chair in mineralogy at Cambridge in order to work on ‘his Induction’. With that change came a drastic reduction in his own practical scientific work and an increasing devotion to the contemplation and attempted direction of other scientists’ observations. The lines of battle which Whewell had but tentatively drawn in 1831 were now in place, and the only question left to be answered was whether chemical notation would answer to practical utility or to philosophical grandeur. ‘Those chemical formulae are the best which best answer their purpose’, concluded Whewell in 1833; ‘and therefore our judgement of what is best must depend on our views with regard to the purpose which those formulae are to answer’.41

4. Practice prevails: the disarming of philosophy

While Whewell directly sparred with Berzelius in the autumn of 1833, the debate over the practical versus philosophical merits of chemical symbols was being negotiated in a different way in a new series of letters in the Philosophical Magazine. The new debate matched Richard Phillips, who opposed all forms of symbolic notation, against Thomas Graham and John Prideaux. Phillips initially complained in the journal that he had been unable to comprehend a recent Royal Society paper by Graham due to its use of inconsistent and unintelligible symbols. In defence, Graham and Prideaux repeated the utilitarian argument for chemical symbols, and further claimed that there was no significant inconsistency between the Berzelian systems and systems presently employed in England. Their response constituted a firmer commitment to the Berzelian system than either Turner or Johnston had exhibited, while at the same time following the London chemists’ mainly pragmatic justification for using symbols in the first place.

Phillips (1778–1851), who was not university educated, had lectured at the London Hospital for sixteen years when he first lashed out at Graham. He made up for his outsider status in academic circles by editing the Annals of Philosophy from 1821 until it was subsumed under the Philosophical Magazine six years later and co-editing the

40 Ibid., p. 10. Whewell here overlooked his own inconsistent use of the symbol $g$ for water.
41 Ibid., p. 10.
latter journal for several years after that. In contrast to Phillips, Graham (1805–1869) had graduated MA from Glasgow in 1823, was currently teaching at Anderson College, and in three years would succeed Turner as professor of chemistry at University College London. Despite his academic training, however, he actually was more concerned than Phillips with practical, and especially industrial, applications of chemistry. A former student of Thomas Thomson, he showed all indications of duplicating Thomson’s efforts ‘to breed up a set of young practical chemists’ in his work at Anderson College, a conviction which also was to motivate his major role in founding the London Chemical Society in 1840.42 The third participant in the debate of 1833, Prideaux (1787–1859), who was closer in age and education to Phillips than to his ally Graham, found himself in Graham’s camp primarily as a result of his practical interest in mineralogical and agricultural chemistry. Eulogized by Robert Oxland as ‘one of the most hard-head[ed] scientific teachers’ at the Plymouth Institution, Prideaux valued Berzelian symbols mainly for their utility in describing the composition of such mundane compounds as fertilizer salts and mineral deposits. His path to supporting Berzelius was more direct than Graham’s, although ultimately less influential.43

Phillips mainly faulted Graham for claiming to use Berzelian notation in spite of clear discrepancies between his Royal Society paper and Berzelius’s Essai sur la Théorie des Proportions Chimiques. Where the Swedish chemist had written water as $\text{H}_2\text{O}$, Graham wrote $\text{H}_2$; similarly, Graham’s notation for phosphoric acid, $\text{P}_2\text{O}_5$, lacked Berzelius’s dash. Phillips proceeded to cart out no less than ten systems of notation which had been presented to the British public in the last decade, all of which differed in some detail or another. If the desired effect of this ‘specimen of confusion’ was to expose the basically arbitrary nature of most current systems, Phillips succeeded: in his example, sodium phosphate, sodium was variously denoted by $\text{Na}$, $\text{N}$, $\text{S}$, and $\text{So}$, phosphate by $\text{P}_2\text{O}_5$, $\text{P}_2\text{O}_5$, $\text{P}_2\text{O}_5$, and $\text{P}_2\text{O}_5$, and water by $\text{H}_2\text{O}$, $\text{H}_2\text{O}$, $\text{H}_2\text{O}$, and $\text{H}_2\text{O}$. But while he might have achieved his limited aim to prove the apparent disarray into which the use of chemical notation had fallen, he failed to perceive the real issues which were at stake in the controversy. In his stubborn effort to decry notation in every possible manner, he was unable to appreciate the crucial fact that it was possible to follow the same set of symbols while disagreeing on theoretical issues. Thus Graham easily countered the direct claim, that his symbol for water lacked Berzelius’s dash, by arguing that he disagreed with Berzelius on the combining proportion of hydrogen but not on

43 Robert Oxland, ‘President’s Address’, Annual Report and Transactions of the Plymouth Institution…, 1 (1878), pp. 28–9. Prideaux’s interest in practical chemistry continued after the notation debate; for many years he taught chemistry and mineralogy at the Cornwall Institution’s mining school in Truro, where, Oxland reports, he ‘turned out young men who have since occupied very important positions as miners and metallurgists in all parts of the world’. Cf. the syllabus of his course reprinted in 21st Annual Report of the Royal Institution of Cornwall (1840), pp. 66–7.
the use of symbols. He replied curtly, and not without a hint of condescension, to the older Phillips:

...in common with Gay-Lussac, and all the chemists of this country who have lately published, I consider water as composed of one atom of oxygen and one atom of hydrogen, a constitution expressed by \( \text{H}_2 \) in the symbolic language of Berzelius. Berzelius himself uses the expression \( \text{H}_2 \), because, from theoretical considerations, which everybody knows, he halves the combining proportion of hydrogen, and therefore makes water to consist of one atom of oxygen united with two atoms of hydrogen.\(^{45}\)

Phillips's more general depiction of the disarray produced by conflicting systems of notation revealed a different misunderstanding of the essentially practical aims of most British chemists and required a more complicated response. Prideaux rose to the challenge, claiming that it was possible to reconcile the different systems as long as a sufficient breadth of translation were tolerated. He presented four systems of notation describing the compound crystallized phosphate of soda:

Rose..............................................2NaO + PO\(^5\) + 24HO.
Turner.........................................\( \text{SO} + \text{P} + 2\frac{1}{2}\text{O} + 12\text{aq.} \)
Johnston ........................................\( \text{P} + \text{SO} + 24\text{H.} \)
My [Prideaux's] scale........................\( \text{SO}_2\text{Ph}_{4}\text{aq}^{24}. \)

All these systems, Prideaux claimed, harmonized with the Berzelian symbol Na\(2\text{P} + 24\text{H} \), 'and are a common language of science, applicable to all nations, and easily acquired'. This was clearly an eccentric definition of 'common', especially by Phillips's (or for that matter Whewell's) standards. From Prideaux's own point of view, however, 'a common language of science' signified a tolerance of individual idiosyncracies, provided that they could be translated into the same basic formula.\(^{46}\)

Given the methodological rift separating Prideaux and Phillips, it is not surprising that the latter did not, as Prideaux had hoped he would, 'revoke his unsparing sentence' on Graham. On the contrary, he responded with increased vituperation in the following number of the Philosophical Magazine. First addressing Graham, he chided the Scottish chemist for following the notation of someone with whom he disagreed on so fundamental a point as the composition of water. 'I cannot agree with you', Phillips concluded, 'that a system is "convenient" which requires so much patching, from the hand even of a professed admirer, to make it express his opinions both as to theory and as to facts'. Turning to Prideaux, he claimed that the Plymouth chemist's remarks were 'inaccurate both with regard to the facts and fancies of symbolizing'. Phillips recognized, but was not satisfied with, the argument that different theories of combination could be expressed under the same system of notation. Regarding the Berzelian symbol \( \text{H}_2 \) for water, he complained that either 'half an atom may be confounded with a whole one, or to prevent it, the innovation must be explained in words which will occupy more time and space than the meaning of the symbol written at full length'. Phillips was similarly unsatisfied by Prideaux's assertion of harmony


\(^{46}\) John Prideaux, 'Remarks on Mr. Phillips's Observations on the Use of Chemical Symbols', Philosophical Magazine, third series, 4 (1834), 41–3. Whewell, it seems, would have concurred with Phillips that the co-existence of so many different systems was damaging to chemistry. Sensing this, Prideaux was careful to note that 'the mathematical notation of Whewell and Brande can hardly be classed as translatable into the Berzelian system.
among superficially different systems: "If, as Mr. Prideaux asserts, these symbols exhibit harmony, it is to me of that variety which has been characterized as "all discord"."  

From Whewell's perspective, the debate which Phillips had initiated was more damaging in terms of the issues it left out than those it raised. Partly because of Phillips's continued effort to decry the alleged convenience of notation, practical questions dominated both sides of the discourse. In responding to the charge of conflicting symbolic systems, Graham and Prideaux attempted to reconcile the different systems to a practical standard which suited chemists, rather than an algebraic standard which alone would have suited Whewell. In a sense, then, the continued presence of reactionaries like Phillips in the debate over notation allowed hard-headed Berzelians to demonstrate the superiority of their system without addressing Whewell's specific claims. As with Turner's use of notation in his chemical textbook, the practical, heuristic applicability of symbols proved a much more popular argument in their favour than any of Whewell's philosophical justifications. Without explicitly recognizing or opposing the missionary efforts of the Cambridge philosopher, most chemists conveniently ignored his prescriptions in favour of convenience.

Late in 1834 Edward Turner solidified the chemists' response to Whewell in the fifth edition of his Elements, the last he would personally supervise before his death two years later. He took that opportunity to codify many of the implicit rules of notation which he had introduced the previous year. The new edition generally took a more systematic stance regarding notation, including a more conscious attempt to conform his table of the elements to Latin or German names. Sodium, potassium, and tungsten, all of which had been abbreviated according to their English spellings in the fourth edition, now received the respective symbols Na, K, and W. Turner also included a new section devoted exclusively to notation, in which he outlined the relative merits of the algebraic and Berzelian systems. He described Whewell's system as 'that which first suggests itself' and faithfully repeated Whewell's rationale for its use. In such a system, he claimed, '[a]ll the elements contained in a compound are thus visibly represented, and the chemist is able readily to trace all possible modes of combination, and to select that which is most in harmony with the facts and principles of his science. He may, and often does, thereby detect relations which might otherwise have escaped notice'.

Despite such an apparent endorsement, however, this position actually only amounted to a faint impression of Whewell's complete philosophical agenda, since it demoted algebra's role from that of a sterling standard of clear thinking to that of a useful instrument in perceiving the nature of chemical change.

As in the previous edition of the Elements, but this time more explicitly, Turner demonstrated exactly where his loyalty to Whewell ended and where his allegiance to Berzelius began. 'Useful as the algebraic chemical formulæ are for the purpose of studying chemical changes', he added in his new section on notation, 'they are sometimes found inconveniently long where the object is merely to express the composition of bodies, and accordingly Berzelius had introduced several abbreviations'. In addition to the dots and dashes which he had already begun to utilize

---

48 Turner died February 1837. His brother Wilton, together with Liebig and William Gregory, edited a sixth edition of the Elements in 1842, which went into another edition the same year. The eighth edition of the popular textbook, published in 1847, was edited by Liebig and Gregory.
49 Edward Turner, Elements of Chemistry, 5th American, from the 5th London edn (Philadelphia, 1835), pp. 150–2. Although the preface is dated November 1834, the publication date is 1835.
in the fourth edition, he mentioned the form \( A^*B^* \) for the first time. He sided with Prideaux's logic against the possible charge of inconsistency, arguing that the combination of elements which was only implicit in such notation would not overly confuse the issue: 'Berzelius often dispenses with the sign +, and writes combined elements side by side, the sign of addition being understood instead of expressed'.\(^50\)

Expanding and systematizing his practice in the previous edition, Turner used algebraic notation only when discussing chemical change, and utilized the whole Berzelian array in all other cases. He never explicitly settled on one system or the other as 'his own', but it is clear from the Elements that he judged each according to its relative practical utility. This judgment ignored Whewell's more fundamental views on symbols, such as the requirement that they do more than express an arbitrary opinion of chemical composition. Although he agreed with Whewell that all theories of composition were equally arbitrary, he made no reference to any higher form of mathematical certainty.\(^51\)

Once he was sufficiently convinced of the provisional worth of a given hypothetical arrangement of elements in a compound, he was quite willing to express that arrangement in Berzelian shorthand.

Turner most clearly demonstrated his willingness to adapt notation to theoretical innovation in his revisions to the section in the Elements on organic chemistry. In the fourth edition, he had made the pessimistic claim that 'chemists are as yet quite in the dark as to the mode in which... elements are arranged' in organic compounds and therefore kept chemical notation entirely out of his lengthy discussion of them. In the next edition, his hopes lifted by German discoveries in the field, Turner expressed confidence that 'the progress of analytical chemistry' was 'daily destroying the distinction' between organic and inorganic compounds. His optimism led to a generous introduction of notation in the revised section, in which he significantly used Berzelian abbreviations as his guide.\(^52\)

Having satisfied himself of the practical application of contemporary organic chemistry theories, he completely (and intentionally) overlooked Whewell's requirement that a proper system of notation should equally reflect all possible combinations of elements and jumped straight to the convenience which Berzelian notation afforded with the abbreviation of complicated formulae. In the working world of chemistry textbooks and scientific journals, practice had prevailed over philosophy. Although Whewell had one last opportunity to promote his philosophy when the notation debate moved to the British Association in autumn of 1835 for its final resolution, among many chemists the decision had already been reached.

5. A committee to the rescue: an ad hoc resolution in the BAAS

When it was suggested in the Committee for Chemical and Mineralogical Science of the BAAS in 1834 that an ad hoc committee be formed in order to introduce a 'uniform set of Chemical Symbols' into British chemistry, notation was already a live issue inside the confines of the British Association. Besides James Johnston's mention of chemical notation in his 1832 report and Whewell's personalized plea for symbols the following year, Turner had privately desired to use the BAAS in order to 'come to an agreement of the English chemists on various important questions of nomenclature, etc.', as early as 1832. Two years later his wish came true, when he was selected secretary of the ad hoc...
committee. The committee sported sixteen members, including several of the chemists who had participated in the debate on notation over the preceding three years. Dalton and Phillips represented the older view, William Prout, John F. Daniell, Whewell and Faraday sided with the algebraic stance, and (with varying degrees of loyalty) Turner, Johnston, Graham, Thomas Thomson and William Gregory lent their support to Berzelius. Turner's administration of his secretarial duties has recently been clarified by W. H. Brock's discovery of a letter he wrote to Prout in January 1835. In effect, Turner called for British chemists to deliver a mandate on the principles which lay behind his use of symbols in the most recent edition of his Elements, including the use of algebraic notation to describe chemical change and the 'awkwardness' of Whewell's method of joining elements in a compound with a plus sign. A year later, in Dublin, the committee presented its decision. As briefly summarized and published in the 1835 Report, it arrived at three conclusions:

1st. That the majority of the Committee concur in approving of the employment of that system of notation which is already in general use on the Continent, though there exist among them some differences of opinion on points of detail.

2ndly. That they think it desirable not to deviate in the manner of notation from algebraic usage except so far as convenience requires.

3rdly. That they are of opinion that it would save much confusion if every chemist would always state explicitly the exact quantities which he intends to represent by his symbols.

These conclusions, by and large, adequately reflected the practical rules for notation which most British chemists had come to adopt on their own by 1835. They are most notable for their lack of prescriptive rigor: apart from the final point, which may have been included as a concession to Phillips and Dalton, practical convenience seemed to be the main rule for deviating from either the continental or the algebraic norm. Since these two standards were not wholly consistent, the committee implicitly advocated the strategy which Turner had adopted in his Elements. Turner further displayed his ability to win a consensus for his approach in a letter accompanying the official report, in which he suggested that Berzelian symbols 'should not be carried further than the dots for oxygen'.

Not surprisingly, both Dalton and Whewell objected to the final committee report. Their objections, however, took on strikingly different forms. While Dalton stubbornly maintained his system against the majority decision and demanded equal time to express his dissent, Whewell all but resigned himself to defeat. Dalton exhumed his

---

53 It is unclear whether Johnston or Turner was directly responsible for suggesting that a committee be formed. Morrell and Thackray (footnote 3, p. 487) imply that it was Johnston's doing, while Brock (footnote 3), p. 34, writes that 'Turner persuaded' the Committee on Chemistry and Mineralogical Science to form a committee on notation. Brock's source, the British Association Report for 1834, does not indicate who made the suggestion. The other members of the committee were Thomas Charles Hope, William Hallowes Miller, Thomas Clark, John Christieon, and James Cuming. It is likely that Christison supported the position of his close friend Turner. On Daniell, see footnote 23 above.

54 Turner to Prout, 30 January 1835, reprinted in Brock (footnote 3), pp. 37–9. Turner wrote that algebraic notation was useful for 'pointedly fixing the Students attention on all the elements concerned in a given change'. Prout's reply (reprinted in its draft form in Brock, pp. 39–41) indicated allegiance to Whewell's positivist position: 'chemical notation...should in all instances express facts only and never hypotheses'.

previous objections to Berzelian symbols, complaining that 'regard must be had to the arrangement and equilibrium of the atoms (especially elastic atoms) in every compound atom' and concluding that a system of 'weights without arrangements' was 'only half of what it should be'. Addressing the BAAS in Dublin, he reasserted his philosophical realism and xenophobic defense of the atom. His set of practical symbols, he claimed, was 'the only one representing nature, and ... if the British Association sanctioned the adoption of the notation of Berzelius, as was desired by many Irish and British chemists, it would virtually have placed an extinguisher upon itself'. He pressed his case even further by distributing lithographed copies of 'Dr. Dalton's proposed atomic symbols' to any interested parties. Fellow chemists observed this flourishing defense of atomic realism with careful respect. Whewell declared his admiration for Dalton's achievements, but found it 'impossible, in the present state of science, to rest satisfied with the arrangement of Dr Dalton'; Turner and Graham kept their opinions to themselves. The most support Dalton would receive came a year later, at the Bristol meeting of the BAAS, when Charles Daubeny diplomatically suggested that pictorial notation might be retained at the level of elementary education.\(^{56}\)

In contrast to Dalton's outspoken dissent, Whewell kept his qualms hidden behind closed doors. In public he put on a brave face, but openly conceded that Berzelius had carried the day. Whewell's unsuccessful attempt to steer the committee's decision his way is clear from Turner's letter which accompanied the report, where after proposing the uniform use of dots to denote oxygen he mentioned that 'indeed, it was suggested by some that these should be rejected, as they merely express theory, and, consequently, vary according to [different views]'. Turner, expressing the majority opinion among committee members, immediately discounted Whewell's methodological objection with the assurance that 'if brevity is not carried any further than this, no bad consequences can follow from a system of notation'. The committee thereby codified what Turner and Johnston had implied all along: what was bad for Whewell's philosophy of science was not necessarily bad for chemistry.\(^{57}\)

Unlike Dalton, Whewell conceded defeat. He also realized that Berzelian notation, which at least partly disputed the realism impelling Dalton's system, was the lesser of two evils. His final statement in the controversy, coming in response to Dalton's dissent, therefore suggested complete support for Berzelius. The actual wording of the statement, however, reflected Whewell's attempt to salvage what he could from the wreckage. In language directly contrary to his arguments in the Royal Institution paper, he praised the advantages which Berzelian notation had over Dalton's: 'Dr Dalton's method supposes a theory, Berzelius only states a fact. The notation of the Swedish chemist shows that such and so many atoms are present. Dr Dalton's, on the other hand, attempts to show their method of molecular arrangement, of which we have no positive knowledge whatsoever'. In recasting Berzelius as a friend of positivism, Whewell consciously attempted to downplay his mainly practical purpose for symbols. His other comment in favour of Berzelius showed even more signs of resignation: 'The chemists of all other nations [have] fallen into the views of Berzelius. The right, and what [is] more, the power, of priority [is] vested in Berzelius...'.\(^{58}\) Whewell's aim in 1831 had been precisely to deny Berzelian notation its right to priority among British


\(^{57}\) Edinburgh New Philosophical Journal, 19 (1835), 393.

chemists and to challenge Berzelius's power. Four years later, he was willing to concede the question of right and forced to concede the power of continental chemistry.

Whewell's failure to subordinate chemistry beneath calculation was indicative of a wider failure to propagate his 'true faith' of induction. Although his History and Philosophy of the Inductive Sciences were successful among some readers, his prescriptions on the status and practice of the descriptive sciences went relatively unheeded. Botanists, geologists, chemists and natural historians continued to proceed through the middle of the nineteenth century as they always had, generally refusing to subordinate their classificatory and historical approach to the standard of mathematics. Whewell's failure to utilize the BAAS as a forum for his views similarly had wider parallels. As with chemical notation, his propaganda efforts in the BAAS turned against him in two other pet subjects, statistics and the study of the tides. He had been an early supporter of statistics in the BAAS, hoping that it would introduce 'some zealous theorists' into what had previously been a purely descriptive discipline. Although he had no difficulty attracting theorists to the BAAS, however, their theories alarmingly tended to be social rather than mathematical. By 1840, he expressed dismay at the 'inflammatory and agitating questions' which were being discussed in the statistics section of the BAAS. This 'wild and dangerous absurdity', as Whewell called the statistical testing of social theory, was one of the main reasons he gave for severing his relations with the British Association in the early 1840s.59 He fared no better with his attempt in the BAAS to show how the study of tides might exemplify the proper direction of a descriptive science by a mathematical theory. After five years of using British Association speeches and funds to promote his 'tidology', he finally despaired of the matter in 1836.60

Whewell's frustration and Dalton's obsolescence each in their own way paid tribute to the stubborn autonomy which British chemists had successfully exerted in the 1830s. As the decade came to a close, the last vestiges of mathematical and traditional authority started to fade. Turner's cautious inclusion of Whewell's prescriptions, which had marked an initial recognition of his powerful social and intellectual location at Cambridge, soon gave way to more fully Berzelian schemes of notation. Thomas Graham, in his Elements of Chemistry (1838), presented the full array of Berzelian symbols, only this time as his own adopted system rather than one of two choices.61 Significantly, Graham and other chemists in his generation were increasingly becoming interested in organic chemistry and their extended adoption of Berzelius reflected that development. As Liebig began to exert new influence on the British chemical community, continental subjects as well as notation became the fashion. The negotiation of notation in England entered a new era.

Acknowledgment

The author wishes to express thanks to Mary Jo Nye for her encouragement and helpful comments.

59 Whewell to Adolphe Quetelet, 2 October 1835, in Todhunter (footnote 6), II, p. 228; Whewell to Robert Murchison, 2 October 1840, in Ibid., pp. 291–2.