Disciplinary Identity And The Chemical Revolution

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Introduction

Historians of science have long been interested in identifying the distinct and separate disciplines of science. Historians of the Chemical Revolution with otherwise radically different historiographical agendas also share this interest. This paper surveys a handful of these discipline-based histories, and calls attention to problems raised for the historiography of disciplinarity by the specificity, originality, and temporality of Joseph Priestley's scientific practices.

Comte's "positive philosophy" is an important source of interest in the disciplinary identity and development of science.[1] Comte called upon historians of science to offset "the pernicious influence" of specialisation –inherent in the disciplinary division of labour essential to the progress of science– by attending to "the relations and concatenations of the sciences." He presented this proposal as a perfection of the division of labour, in which the dialectic between the specialised practitioners of the different scientific disciplines and the newly emergent historians of science, or "positivist philosophers," specialising in the study of "general scientific traits," would facilitate the indefinite progress of science, while preserving its clearly demarcated identity. Comte linked the unity and progress of science to the disciplinary coordination of individual investigators serving, without necessarily comprehending or being concerned with the epistemological and sociological interests of the whole.

Interest in the disciplinary identity and coordination of eighteenth-century chemistry outlasted the positivist hegemony that formed it; it is clearly detectable among post-positivist and post-modernist historians of chemistry who otherwise distanced themselves from the synthesising and reforming spirit of positivism. Whereas positivist historians viewed the Chemical Revolution as the moment when chemistry made the transition from a nonscientific to a scientific discipline,

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post-positivists, like Evan Melhado, Carleton Perrin, and Robert Schofield, related it to the shifting boundaries of the pre-existing scientific disciplines of physics and chemistry. While sociologically minded scholars such as John Christie and Jan Golinski identified eighteenth-century chemistry as a "didactic discipline", other scholars, like Lissa Roberts, Jonathan Simon, Mi Gyung Kim, and Ursula Klein, called for the "history of chemistry's disciplinary journey from its self-defined status as art to its recognised status as science.[2] More generally, sociologists of knowledge like Steve Shapin emphasised the important role of the construction of disciplines and their boundaries in the development of science. Indeed the sociological ascendancy in late –twentieth-century history of science ushered in "a remarkable expansion of interests in scientific disciplines, their origins, fusions, fissions, and extinctions".[3]

Historiographies of the Chemical Revolution

A brief survey of positivist and post-positivist interpretations of the Chemical Revolution highlights both the interpretive flexibility and limitations of the historiography of disciplinarity. The demarcationist form of this historiography characterised the positivist image of the Chemical Revolution as the "postponed Scientific Revolution in chemistry". On this interpretive model, scientists merely had to deploy the unique scientific method developed during the Scientific Revolution of the seventeenth century to ensure cognitive progress in their respective disciplines. Lavoisier did this in a series of crucial quantitative experiments on combustion and the calcinations of metals, which established the central role of oxygen in the workings of nature. Phlogistians like Joseph Priestley, on the other hand, did not appreciate chemistry's break with its non-scientific past because they failed to recognise and abide by the disciplinary and methodological strictures of the new chemistry.[4] On this interpretation, Lavoisier's modernist sense of the autonomy of chemistry contrasts vividly with Priestley's premodern vision, of a unified cosmos grounded in God's providential presence.[5]

Post-positivist historians of science in the 1960s and 1970s challenged this interpretation of the Chemical Revolution.[6] They identified science with theory and the history of science with the succession or conjunction of different and distinct, if not incommensurable, paradigms or doctrines. The historiography of disciplinarity accordingly shifted its focus from the domain of methodological rules and experimental strictures to the realm of doctrinal conformity and theoretical commitment. It focused not on the monolithic demarcation between scientific and nonscientific disciplines, but on the complicated intrascientific relations between the disciplines and doctrines of physics and chemistry, thereby bringing to the fore the hallowed problem of the autonomy of chemistry and the totalising ambitions of physics.

Post-positivist scholars, like T. S. Kuhn, Arnold Thackray, and Robert Schofield, upheld the autonomy of eighteenth-century chemistry by rejecting the positivist assimilation of the Chemical Revolution to the Scientific Revolution, emphasising instead the work of Lavoisier's Stahlian predecessors in the eighteenth-century chemical community. Thus, Thackray and Schofield emphasised the "profound failure of the Newtonian program" in eighteenth-century chemistry and argued that Lavoisier did not free chemistry from the influence of George Ernst Stahl, so much as rationalise Stahl's program in a way that resisted the premature and unhelpful solicitations of corpuscular physics.[7]

Other post-positivist scholars replaced this pleasing myth of the liberation of chemistry with a more nuanced sense of the disciplinary horse-trading that characterised physics and chemistry in the eighteenth century.[8] According to Perrin, while Lavoisier pursued a program of methodological reform, in which he used physical instruments and measurements to solve chemical problems, the revolution he envisioned in the fall of 1772 "was a conceptual and theoretical one", based on the introduction of the idea of the gaseous state into the pre-existing science of chemistry promulgated by Guillaume Francois Rouelle. While Perrin defended the orthodox view that Lavoisier "accomplished a revolution *in* chemistry", Arthur Donovan claimed that Lavoisier deployed the methodology of Jean-Antoine Nollet's experimental physics to engineer a "revolution *into* chemistry." Melhado, on the other hand, identified Lavoisir as a follower of Herman Boerhaave, who approached the chemical fixation and liberation of air as "aggregative phenomena", produced by "free [rarefying] fire" or caloric" rather than by "fixed [attractive] fire" or phlogiston. According to Melhado, "the Chemical Revolution was generated externally by physics", which transformed an already existing scientific discipline "and then withdrew from it".

Donovan, Melhado, and Perrin never resolved their interpretive differences, thanks in part to Perrin's untimely death, but also to historiographical disagreements that rendered an effective resolution unlikely. While Perrin remained attached to the positivist idea that scientific progress involves the replacement of older, less adequate statements about the world with newer, more adequate statements, Donovan and Melhado stressed the globalist view that scientific revolutions involve changes in the methodological and ontological assumptions that guide the formation of theoretical statements and principles. On this view, Lavoisier achieved a revolution in chemistry only because "his successful refutation of the phlogiston theory also involved transforming chemistry" by incorporating into it methodological or ontological principles derived from physics. According to Donovan, a just appreciation of the Chemical Revolution required recognition of the historical mutability not only of the facts, concepts, theories, methods, and aims of science, but also of its disciplinary structure.

The Doctrine of Airs

Donovan's historicist admonitions sensitise us to two possible problems with the application of the historiography of disciplinarity to the interpretation of Priestley's science. The first problem concerns the specificity of Priestley's science and the capacity of familiar (modern) disciplinary boundaries to accommodate his "doctrine of airs". The other problem, which will be dealt with in the next section, draws attention to possible 'tensions' between the synchronic structure of disciplines and the diachronic course of Priestley's natural philosophy.

An overly narrow focus on positivism's familiar interest in the deductive unity of the disciplines of physics and chemistry leads to a retrospective distortion of Priestley's science. This is evident in Schofield's physicalist construal of Priestley's opposition to Lavoisier's chemistry, as well as in those interpretations of the Chemical Revolution that identify it as a Second Scientific Revolution, which occurred between 1780 and 1850 and involved conceptual and institutional transformations that separated early modern science, or natural philosophy, from the autonomous disciplines of modern science.[9]

Fortunately, more recent scholars, like Simon and Kim, are sensitive to this problem, focusing on the relation between chemistry and medicine, rather than chemistry and physics, in the eighteenth century. More salient for the current discussion is the suggestion made by the late Larry Holmes that the Chemical Revolution was a revolution in "pneumatic chemistry", understood not in its modern guise as a subdivision of general chemistry, but in its eighteenth-century grandeur as an interdisciplinary activity that encompassed physics, chemistry, and medicine.[10]

Taking his cue from Henry Guerlac's suggestion that the Chemical Revolution involved the synthesis of continental analytical chemistry and the results of British pneumatic chemistry, Holmes argued that whereas the continental tradition represented the activity of successive generations with a distinct disciplinary identity, pneumatic chemistry was pursued by "people who were not identified primarily as chemists" and whose results were "not necessarily seen by contemporaries as more particularly belonging to chemistry rather than physics, or medicine". Thus, Stephen Hales, the founder of pneumatic chemistry, was a Newtonian natural philosopher, with no special interest or training in chemistry; Joseph Black was a "philosophical chemist," concerned with the role of chemistry in medical education; David McBride and William Brownrigg were practicing physicians; Henry Cavendish was a physicist; and Priestley approached the doctrine of airs from the perspective of a comprehensive philosophy of man and nature. It is also important to note that Priestly was indiscriminately interested in the physical, chemical, and medical properties of the dozen or so airs he prepared and isolated. Nor was his abiding interest in the "purity" of the atmosphere a chemical one. Rather, Priestley's search for the "provisions" in nature, such as vegetation and the agitation of seas and lakes, to offset the "vitiation" of the atmosphere, caused by respiration, combustion, and putrefaction, expressed medical and social concerns, as well as a broader, theistic view of a benevolent nature attuned to the preservation of animal life and human happiness.[11]

When Priestley developed his phlogistic explanations of the compositions of the airs and the role of respiration and vegetation in the balanced economy of nature, he loosened phlogiston from its traditional Stahlian identification with the principle of inflammability. He also developed a new "doctrine of airs", which as Ferdinando Abbri has noted was well received by physicists, chemists, and physicians all over Europe.[12] According to Holmes, it was this new rival program, stemming from Hales and culminating in Priestley, and not the traditional chemical doctrine of Stahl, that Lavoisier had in mind, and with which he aligned himself, when he referred to "a revolution in physics and chemistry". Noting that the "new chemistry" encountered Stahl, and not Priestley, in Paris and Germany, Holmes called for a more decentered view of "the chemical revolution as a set of different kinds of event within different contexts".

Disciplines and Discoveries

Holme's analysis supports the "interactive" model of the Chemical Revolution championed by Ferdinando Abbri and Bernadette Bensaude-Vincent.[13] This model interprets the spread of the "new chemistry" not in terms of the gradual subsumption of the peripheries of the scientific culture under the Parisian centre, but in terms of a dynamic interaction between relatively autonomous, local cultures of chemistry, each with its own disciplinary identity. But Holmes did not take his contextualising interest far enough. His view of the Chemical Revolution remained centered on Lavoisier, and although he rescued "pneumatic chemistry" from its retrospective identification as a subdiscipline of general chemistry, he still presented it in terms of the disciplinary configurations of physics, chemistry, and medicine, which carry their own retrospective baggage. It is only by linking the scientific dimension of Priestley's self-proclaimed identity as an "aerial philosopher" to its broader philosophical and social context that we can fully appreciate his idiosyncratic notion of the disciplinary nature of the "doctrine of airs" and its relation to general chemistry.[14]

When Priestley identified himself as an "aerial philosopher", he registered not only his ignorance of traditional chemical theory and practice; he also elevated the disciplinary status of the chemistry of gases above that of general chemistry. Work on the mineral acids and their gaseous products led Priestley to conclude that it was only by studying them in the "aerial state", bereft of the moisture united to them in the liquid state, that their real "nature and affinities" could be determined with any certainty. Impressed with the many other discoveries and myriad implications of gas chemistry, Priestley ventured to entertain the possibility that, eventually, chemistry would be conducted almost entirely in the "aerial state":

"The reason of my great expectations from this mode of experimenting is simply this, that, by exhibiting substances *in the form of air*, we have an opportunity of examining them in a less compound state, and we are advanced one step nearer to their primitive elements. It will be a great satisfaction to me, after that part which I have taken in this business, to be a*spectator* of its future progress, when I see the works in so many, and so good hands, and everything, in so rapid and so promising a way".[15]

While it is true that Priestley approached the study of gases with a well-defined repertoire of experimental techniques and instrumental practices, his sense of the progress and future hegemony of pneumatic chemistry does not rest on a clearly articulated vision of its disciplinary structure and domain of application. Its open-ended, sublime character signifies his view of the role of natural philosophy in the endless progress and perfectibility of human nature through the comprehension of an infinite world, bristling with "novelty" and grounded in God's benevolent fecundity.

These considerations lead us to question the role of the historiography of disciplinarity in the interpretation of Priestley's science. The valorisation of communal unity and conformity associated with this historiography –whether in the form of positivism's vision of the unity of science, Kuhn's model of normal science, or Foucault's disciplinary structures of power– obscures the dimension of endless novelty, or "discovery", crucial to Priestley's scientific practice. An adequate historiography of the Chemical Revolution must do justice to the well-worn, but perspicuous, image of Priestley as a "comet in the system", offsetting in the manner of a Newtonian active principle, the stifling tendencies of disciplinary unity and conformity with a plethora of new discoveries and a mode of theory and practice based on a synoptic sense of man's unfolding comprehension of nature.[16]

Three lines of response to the Priestley problem are open to the historiography of disciplinarity. It can simply exclude Priestley's science from its domain, accommodate it in an *ad hoc* manner, or develop a more encompassing, dynamic notion of practice and disciplinarity. The first response, located in the works of Jan Golinski and Simon Schaffer, treats disciplinary structures as inherently communal and practical and locates the age of disciplinarity in the second scientific revolution of the early nineteenth century.[17] On this account, Priestley's discoveries contributed to, but did not participate in, the disciplinary identity of modern chemistry. This response is reminiscent of earlier historiographies of the Chemical Revolution, which placed Priestley on the 'wrong' side of the dividing line between science and nonscience, mature and immature science, though the division is now presented as an historical one between the "development of specialisation and professionalism" and the gentlemanly natural philosophy of the Enlightenment that preceded it. Still, it seems to be a matter of old (normative) wine in new (naturalistic) bottles. However, this line of response to the Priestley problem can be given a more interesting and historically informative construal, which throws light on important differences between chemistry in France and Britain in the eighteenth century. It should be remembered that Priestley rejected the imposition of disciplinary uniformity involved in the spread of the French system of chemistry in the name of a liberal individualism that refused to bend the knee to any arbitrary "authority", civil or philosophical. Besides increasing our appreciation of the complexity of the Chemical Revolution, this aspect of the dialectic between Priestley and the French chemists suggests that the historiography of disciplinarity, especially in its Foucauldian form, is more likely to be applicable to the science of those countries, such as France, German, and Austria, where the "ideal of bureaucracy and 'police'", was actualised more than in the "much less bureaucratised" Britain.[18]

The second option, also floated by Golinski, emphasised the "capacity of individuals for autonomous self-expression". Resisting the "powerful sway of disciplinarity," some individuals "creatively" manipulate available resources to forge their own autonomous identity.[19] This response appeals to common sense, but only by sullying historical understanding with the introduction of the unhistorical, obfuscating notion of personal creativity. The spectre of whiggism also haunts this response, imposing on eighteenth-century natural philosophy the nineteenth-century distinction between "genius" and "discipline".[20]

The third option treats disciplines not as rigid structures dominating a unified and immobile scientific field, but as domains of development articulated within a complex and dynamic field of inquiry encompassing science and non-science. This perspective comports well with our growing sense that the Chemical Revolution was not a monotonic moment of disciplinary purification or isolation, but a complex, multidimensional episode, a veritable "mangle of [disciplinary] practices". It also recognises that the "mangle" of history can be liberating and constraining, serving the interests and extending the power of some, while restricting and constraining the activities of others: it reflects the Janus face of the Enlightenment.[21]

Above all, this perspective emphasises the need to offset with historicist vigilance the retrospective tendency of the historiography of disciplinarity to speak of past scientific disciplines as *"if they were those obtaining or normative in present-day science"*.[22] Clearly, they were not.

Notes

[1] See Auguste Comte, *Introduction to Positive Philosophy*, ed. and trans Frederick Ferré (Cambridge, MA: Hackett, 1988), 1-33.

[2] Lissa Roberts, "Setting the Table: The Disciplinary Development of Eighteenth-Century Chemistry as Read through the Changing Structure of Its Tables," in *The Literary Structure of Scientific Argument: Historical Studies,* ed. P. Dear (Philadelphia, PA: University of Pennsylvania Press, 1991), 99-132, on p. 99.

[3] N. Jardine, "A Dip into the Future," *Studies in History and Philosophy of Science* 20 (1989): 15-18, on p. 17.

[4] See John G. McEvoy, "Positivism, Whiggism, and the Chemical Revolution: A Study in the Historiography of Science," *History of Science* 31 (1997): 1-33.

[5] See John G. McEvoy, "Modernism, Postmodernism, and the Historiography of Science," *Historical Studies in the Physical and Biological Sciences* 37 (2007): 383-408, on pp. 387-393.

[6] See John G. McEvoy, "Postpositivist Interpretations of the Chemical Revolution," *Canadian Journal of History* 36 (2001): 453-469.

[7] See T. S. Kuhn, "Robert Boyle and Structural Chemistry in the Eighteenth Century," *Isis* 43 (1952): 1-23; R. E. Schofield, *Mechanism and Materialism* (Princeton, NJ: Princeton University Press, 1970); A. Thackray, *Atoms and Powers* (Cambridge, MA: Harvard University Press, 1970).

[8] See the discussion between Perrin, Donovan, and Melhado in *Isis* 81 (1990): 259-276.

[9] See R. E. Schofield, "Joseph Priestley: Natural Philosopher," *Ambix 14* (1967): 1-15.

[10] F. L. Holmes, "The 'Revolution in Physics and Chemistry': Overthrow of a Reigning Paradigm or Competition between Contemporary Research Programs," *Isis 91* (2001): 735-753.

[11] See John G. McEvoy, "Joseph Priestley, 'Aerial Philosopher': Metaphysics and Methodology in Priestley's Chemical Thought, 1772-1781, Part 1," *Ambix* 25 (1978): 1-55; "Part 2," *ibid*, 93-116; "Part 3," *ibid*, 153-175; "Part 4," *Ambix* 26 (1979): 16-38.
[12] See F. Abbri, "The Chemical Revolution: A Critical Assessment," *Nuncius* 4 (1989): 303-315.
[13] See B. Bensaude-Vincent and F. Abbri, eds. *Lavoisier in European Context: Negotiating a New Language for Chemistry* (Canton, MA: Science History Publications, 1995).
[14] See, e.g., McEvoy, "Joseph Priestley: 'Aerial Philosopher'."
[15] Joseph Priestley, *Experiments and Observations on Different Kinds of Air*, 3 vols (London: J. Johnson, 1774-1777), vol. 3, ix.
[16] See John R. Clarke, *Joseph Priestley: A Comet in the System* (San Diego: Torch Publications, 1990).
[17] Simon Schaffer, "Scientific Discoveries and the End of Natural Philosophy," *Social Studies of Science* 16 (1986): 387-420; Jan Golinski, *Making Natural Knowledge: Constructivism and the History of Science* (Cambridge: Cambridge University Press, 1998), 66-78.
[18] Jay Goldstein, "Foucault Among the Sociologists: The 'Disciplines' and the History of the Professions," *History and Theory* 23 (1984): 170-192. See also John G. McEvoy, "Priestley Responds to Lavoisier's Nomenclature," in *Lavoisier in European Context: Negotiating a New Language for Chemistry*, eds. B. Bensaude-Vincent and F. Abbri (Canton, MA: Science History Publications, 1995). pp. 123-142, on pp. 132-133.
[19] Golinski, *Making,* p. 78.
[20] Schaffer, "Scientific Discoveries," pp. 406-413.
[21] For 'disciplines' as liberating rather than constraining see Robert E. Kohler, "The Constructivists' Tool Kit: Essay Review of Jan Golinski, *Making Natural Knowledge*," *Isis* 90 (1999): 329-331.
[22] Steven Shapin, "Discipline and Bounding: The History and Sociology of Science as Seen through the Externalism-Internalism Debate,"