1 HOW NATURAL PHILOSOPHERS CAN COOPERATE

THE LITERARY TECHNOLOGY OF COORDINATED INVESTIGATION IN JOSEPH PRIESTLEY'S *HISTORY AND PRESENT STATE OF ELECTRICITY* (1767)

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Cheerfulness and social intercourse do, both of them, admirably suit, and promote the true spirit of philosophy.
(2:164)

Recent studies of the rhetoric of science have emphasized the competitive struggle played out through scientific texts. Scientific publications are seen as persuasive briefs for claims seeking communal validation as knowledge (Latour and Woolgar; Knorr-Cetina). Moreover, individual texts have been seen as part of a negotiation process among competing interests that may result in statements of knowledge different than those proposed in the initiating texts (Myers; Collins; Latour). During these struggles authors draw on many extratextual resources (social, economic, intellectual, and empirical) which are deployed in the text

(Collins and Pinch; Callon, Law, and Rip; Rudwick). Only after communal acceptance do these claims take on the appearance of irrefutable truths stated with objective authority transcending the urging of an author (Latour).

Genres of scientific writing can be seen as recurrently successful rhetorical solutions to the persuasive problem of advancing claims within an empirical research community. Communally persuasive forms of representing empirical experience and structuring compelling arguments upon that experience have resulted in claims appearing to be proven knowledge, except to those who know of the local struggles. The standardization of textual form has helped to regularize and focus the struggle of scientific writing, even while it has served to hide that struggle (Bazerman, chap. 2).

Nonetheless, an older tradition has considered scientific activity as more than competitive play. Scientific communication has most often been conceived of as part of a cooperative endeavor. The charter myth of this tradition is Sir Francis Bacon's description of Salomon's House in *The New Atlantis*. Here Bacon describes a cooperative bureaucracy of thirty-six field researchers, reviewers of the literature, experimenters, experimental designers, theorists, and applied technologists. Bacon anticipated no particular communication difficulty in this cooperative project, beyond the general linguistic problem of the four idols. Later in the seventeenth century, this cooperative, bureaucratic model inspired a number of organizational decisions of the French Royal Academy and the British Royal Society. However, personal interests and disagreements soon tore at the fabric of such an untroubled plan, and a communication system which facilitated and structured disagreement took shape over the next century (Bazerman, chap. 3).

Despite the systemic competitiveness of modern science, when we remove ourselves from the daily hand-to-hand combat of scientific argumentation, we can perceive large patterns of cooperation and the communal construction of a shared knowledge. This knowledge is not dictated by a single text or monumental figure (whether God, Aristotle, or Newton), but is advanced (sometimes slowly, sometimes rapidly, sometimes spasmodically) through the joint endeavors of large numbers of people. Not only are little details filled in and puzzles worked out within static paradigms, but major novel findings appear and are absorbed, theories are modified and replaced, and knowledge moves in startling and unanticipated directions. To be persuaded of the overall cooperative pattern of scientific work, one need only contemplate the remarkable changes currently being wrought and absorbed by diverse researchers in "hot" areas such as superconductivity, fundamental forces, viral biochemistry, and neural physiology. Indeed many modern commentators of science make cooperation an essential component of scientific activity and communication (Merton; Ziman; Garvey).

The Puzzle of Cooperation

Noticing that cooperation seems to occur, however, does not let us know how it happens, nor why the cooperation should seem to be as enduring and fundamental as it appears to be in science. Persuasion and cooperation as we know from political and other familiar everyday realms are uncertain and fragile phenomena. Beliefs seem to change rapidly, alliances fall apart, and cooperation often needs to be cemented by laws, money, and coercion. If even the degree of cooperation we manage in everyday affairs remains beyond our full comprehension, how can we begin to account for the much more remarkable cooperation evident in scientific work, a cooperation which seems to span religions, philosophies, national boundaries, and centuries? However, until we have as concrete, detailed accounts of the microprocesses by which cooperation and coordination occur as we do of competitive processes, cooperation and coordination may only appear to be value-laden suppositions rather than actual social activities. This chapter, accordingly, offers a microanalysis of the cooperative mechanisms of one eighteenth-century text that was self-consciously constructed to foster cooperation and that foreshadows a number of features of modern scientific papers. This analysis reveals the many levels on which coordination needs to be achieved through language and the tension which needs to be maintained between cooperation and competition, codification and originality, if communal endeavor of science is to move forward.

Certainly early science did not seem to achieve the cooperative complexity and coordination of contemporary science, despite Bacon's high hopes. Rather than building on one another's theories, authors were as likely to attempt to supplant each other's claims. Authors rarely constructed claims that explicitly integrated a wide range of the claims of others. Even the Baconian hopes for an appeal to the facts did not lead to philosophic harmony, as facts themselves became a matter of dispute. Within this atmosphere, local cooperation was only created by the dominance of strong individuals who set the national theoretical terms and research agendas, supported by institutionalized power; Newtonianism and Cartesianism, although occasionally communicating in individual ad hoc circumstances, more often fired salvos across the English channel (Bazerman, chap. 4).

While science remained small, with relatively few results to coordinate and few compelling challenges to the hegemony of the brilliant works of early giants, such ad hoc cooperation as existed through unsystematic familiarity with each others' works from travel, correspondence, and publications was perhaps adequate to carry the communal work of science forward. The emergence of societies and journals helped create regular forums for communication among scientists and organize the communication practices (Bazerman, chap. 5); however, as natural philosophic findings proliferated in the eighteenth century, cooperation had to be explicitly achieved within the substance of the communications. Textual mechanisms needed to be developed to coordinate the work and emerging perceptions of researchers widely dispersed temporally, geographically, and theoretically.

Joseph Priestley's 1767 book *The History and Present State of Electricity* explicitly takes up the challenge of fostering cooperation among the growing number of electricians and drawing new participants into this emerging research community. Besides expressing concern for the benefits of joint work, the book employs many textual mechanisms that integrate past, present, and future work in the field. Through a comprehensive review of the literature Priestley establishes the corpus of communal experience and organizes it around problems and principles that define an evolving state of knowledge and research agenda. A list of generalizations emerging from that communal history provides a common knowledge base for continuing work; a discussion of the major theories sorts out the conceptual meaning of research; a list of open issues suggests directions for research; and a historical review of the development of apparatus and practical suggestions for construction provide a common material basis for generating phenomena to be investigated. Besides trying to establish coherence and focus within a research front emerging from a shared understanding of past work, Priestley is concerned to draw new researchers into the communal project, so he provides practical suggestions for carrying out experiments and a series of amusing experiments to attract and train neophytes. Finally he provides narratives of his own work to demystify the process of investigation and to provide exemplars of work that might be carried on with only humble means. With our current, limited knowledge of the development of textual features of scientific writing, we cannot unequivocally credit Priestley with invention of the textual devices he employs nor can we trace a direct line of evolution to current cooperative literary practices.[1] Yet Priestley's thoroughgoing interest in fostering coordinated work of an extensive community offers a striking starting point for examining the complexity of cooperative textual machinery that has developed to coordinate the voluminous and undeniably competitive work of contemporary science.

Priestley and Eighteenth-Century Electricity

Electricity by the mid-eighteenth century was a proliferating area and presented much that could use coordination. The modern study of electricity is usually dated from William Gilbert's *On the Magnet* (1600), which includes one chapter on the attractive power of rubbed amber, known since classical times. Gilbert noted a number of other substances that showed a similar property. During the seventeenth century a few items were added to the list of electricals, various theories were presented to account for the phenomenon, and electrical repulsion was noticed for the first time. At the beginning of the eighteenth century, however, the invention of the electrostatic generator made possible the discovery and investigation of such phenomena as luminosity, sparks, shocks, conduction, induction, and the difference between two varieties of electricity. The improvements of these machines and the 1745 invention of the Leyden jar (the modern condenser) permitted experiments with charges of increasingly great power; medicinal and lethal effects were noted. By 1750 Benjamin Franklin had presented evidence of the equivalence of lightning and electricity, setting off a series of investigations into atmospheric electrical phenomena. Electricity was literally exploding across the mid-eighteenth-century natural philosophic scene.[2]

Although Joseph Priestley (1733–1804) had an interest in natural philosophy during his own education and early career as dissenting minister and schoolmaster, he did not actively pursue scientific studies until the mid-1760s when Matthew Turner, his colleague at Warrington Academy, offered a course of lectures in chemistry (Schofield, 8). Priestley was to achieve his greatest fame in this area through the discovery of oxygen in 1774. Nonetheless, electricity and not chemistry provided the subject of Priestley's first investigations and publications.

We do not know exactly when Priestley began to work on electricity, but by late 1765 on a trip to London he arranged an introduction to Franklin and several other prominent electricians to gain their support (see the letter from John Seddon to John Canton in Schofield, 14). Franklin encouraged him in his plan to write a "history of discoveries in electricity," and helped arrange for the requisite books (Priestley, *Autobiography*). Franklin, John Canton, William Watson, and Richard Price remained his correspondents, mentors, and benefactors over the next year as he wrote *The History and Present State of Electricity*.

The first, longer half of the lengthy book (432 of 736 quarto pages in the first edition) is a detailed history of all investigations and discoveries in electricity from the time of the ancients to his day. In its synoptic command, attention to empirical details in the literature, and its open-ended attitude, it can be seen as one of the earliest versions of the modern genre of review of the literature.

The second half of the work, not indicated in any of Priestley's early plans, consists of seven additional parts: a list of general properties of electricity then known; a discussion of the history of electrical theories including a detailed comparison of two major theories; some general considerations on the current state of electrical research and a series of queries to direct future work; descriptions and directions for constructing electrical machines; a set of procedural advice (or practical maxims) for those wishing to carry out electrical experiments; directions for carrying out entertaining demonstration experiments; and a description of his own new experiments on the subject. As the first half may be designated the history, this latter half may be said to be the "current state of electricity." Much of this material is presented in no other previous work on electricity. Although today we might find the various kinds of materials presented in this latter half in a variety of places, ranging from children's activity books through advanced textbooks, equipment manuals, and research journals, we are not likely to find them all under the same cover.

Doing Natural Philosophy by Doing History: Priestley's Philosophic Framework

Although this odd mixture of things may appear to be a neophyte's grab bag, talking about everything he sees with little sense of design, such lack of design is unlikely, for each part of the book is introduced by several pages of explicit description and rationale for the literary procedures that follow. Moreover, at Warrington Academy Priestley had regularly delivered a series of lectures on oratory and criticism (eventually published in 1777) as well as a course of lectures on the theory of language (printed privately in 1762). He was a self-conscious user of language, and his procedures in *The History and Present State of Electricity* are consistent with his teachings on rhetoric (see Moran).

His rhetorical practices, moreover, are a self-conscious attempt to realize his millenarian vision of human progress. Particularly relevant here is his understanding of the role of historical discourse in increasing human wisdom, for it is a history of electricity that he tells and it is as participants in a historical process that he addresses his readers.[3]

As instructor at Warrington Academy since 1761 he had been delivering a series of lectures on history (later published in 1788). In these lectures he argues that the study of history "strengthens the sentiments of virtue" by showing us the characters of the many kinds of humans and "improves the understanding" by extending our experience. In particular, study of the history of natural philosophy presents edifying portraits "of genius in such men as Aristotle, Archimedes, and Sir Isaac Newton, [which] give us high ideas of the dignity of human nature, and the capacity of the human mind" (120).

Moreover, the history of natural philosophy increases our individual empirical experience by attaching us to a community of experience. Priestley declares, "the most exalted understanding is nothing more than the power of drawing conclusions, and forming maxims of conduct, from known facts and experiments, of which necessary materials of knowledge the mind is wholly barren" (108). Understanding is based on experience to form the proper associations.[4] But each individual is limited, so only through history can we come to share in the experience of others. For "the improvement of human kind and human conduct, and to give mankind clear and comprehensive views of their interest, together with the means of promoting it," Priestley felt "the experience of some ages should be collected and compared, that distant events should be brought together" (108). Natural philosophy gives order to the accumulated human experience, so that we may then choose wisely about our lives and improve the human condition.

Priestley himself seemed to have a strong synoptic grasp of history revealed in his invention of the historical time line. Using the bar graph for the first time to represent historical duration (Funkhouser), Priestley published in 1765 an extremely popular *Chart of Biography*, which went through over fifteen editions by 1820, and in 1769 an equally popular *Chart of History*, which also had at least fifteen editions by 1816 (Fulton, 6–7). By this now-common technique he was able to give graphic shape to the sweep of history. This sense of the sweep of history is essential to the vision of the *History of Electricity*. Moreover, he reveals an open-ended attitude toward the historical process by leaving a blank space at the far end of the *Chart of History* for the reader to fill in the developments of the last decades of the eighteenth century. Again this open-ended sense of the historical process imbues the electricity book. He does not pretend that electrical knowledge is complete and history ends with his account. Rather he views electricity as an evolving practice and investigation, caught at a present moment or state of development and leading into an unknown future.

Priestley's concern for progressive historical improvement of life is founded in his millennial theological positions concerning the perfectibility of man led by a benevolent deity (see Hiebert; Laboucheix; McEvoy) and consonant with his radical politics, including support of both the American and French Revolutions (see Crosland, "Image"; Fruchtman; Kramnick; Priestley, *Autobiography*).[5] In his writings on education, Priestley turns this concern into a practical program of training young men for a life of worldly activity to replace the purely clerical education common at his time (*An Essay on a Course of Liberal Education for Civil and Active Life*, 1765). Natural philosophy has an obvious place within such a theology, politics, educational plan, and progressive view of history. Natural philosophy reveals the benevolence and wisdom of God's plan and offers humans a way to participate actively in the fulfillment of that plan.[6]

Within these theological, historical, educational, and rhetorical contexts, Priestley's aim for his account of electricity becomes clear: to further the communal work of electrical investigation. The preface to the first edition of the *History and Present State of Electricity* keeps returning to the theme of how this history and others like it may advance the progress of science; for example, "once the entire progress, and present state of every science shall be fully and fairly exhibited, I doubt not but we shall see a new and capital aera commence in the history of all sciences" (1:xviii).[7] Later he states even more directly, "To quicken the speed of philosophers in pursuing this progress, and at the same time, in some measure, to facilitate it, is the intention of this treatise" (2:53–54). Moreover, in a simplified version published the year after (1768), he reveals his plan comprehensively: "My principal design was to promote discoveries in Science, by exhibiting a distinct view of the progress that had been made hitherto, and suggesting the best hints that I could for continuing and accelerating that progress" (*Familiar Introduction*, v).

A History of Natural Philosophy: Part 1

The first step in this project of furthering the communal work is to gather together the accumulated experience of electricity by natural philosophers. As Priestley comments in the preface to the first edition, "At present, philosophical discoveries are so many, and the accounts of them are so dispersed, that it is not in the power of any man to come to the knowledge of all that has been done, as a foundation for his own inquiries. And this circumstance appears to me to have very much retarded the progress of discoveries" (1:vii). Although this comment may be familiar in the twentieth century, it represents an attitude not generally reflected in natural philosophic texts before this time. Generally references to the work of others was perfunctory, if present at all, and little attempt was made to make systematic sense of the previous literature. Often the writers seem unfamiliar with relevant published work. Franklin, in the distant colonies, presents an extreme example; he began his work with only the aid of a popular summary of contemporary work published in the *Gentleman's Magazine*. Even after he became familiar with a wider range of work, his publications rarely mentioned any historical work and gave only passing mention to the work of his contemporaries.

The most extensive discussion of the electrical literature Priestley had seen before writing his history was the four-page bibliographic appendix to Desaguliers' 1742 forty-eight-page pamphlet, *A Dissertation Concerning Electricity*, which elaborates and gives citations for items mentioned in the main text. A more extensive German summary of the literature and annotated bibliography by Daniel Gralath did not come into Priestley's hands until after the first edition had been published; Priestley used Gralath's work to revise the second edition.

Priestley took very seriously the task of gathering the accumulated experience of prior electricians. He insisted on reading, wherever possible, the original texts of all his predecessors. Much of Priestley's correspondence in this period concerns his attempt to obtain rare volumes (Schofield), and he apparently incurred large expenses in this regard (see Crosland, "Practical Perspective"). In the bibliography of his book he also requests his readers to send him volumes he has not yet seen.

To establish the immediate connection between the sources and his retelling, he footnotes with specific page references each text quoted, summarized, or discussed. About half of the pages of the historical section have at least one reference note and some have as many as five or six. Except for secondary format differences, Priestley follows modern footnote practice. He also includes a bibliography of all items on electricity he had heard of (sixty-three items in the first edition and seventy-five in the second and ensuing editions) and also notes the volumes which he had consulted (thirty for the first edition and forty-three for later editions). In addition, a detailed index identifies where each author is discussed.

In giving such care to identify sources he emphasizes that he is writing a history of natural philosophy embodied in publications rather than a Baconian natural history of the phenomena themselves. Priestley comments, for example, on Franklin's *New Experiments and Observations on Electricity*: "Nothing was ever written upon the subject of electricity which was more generally read and admired in all parts of Europe than these letters. There is hardly any European language into which they have not been translated" (1:192). The history of electricity is in part the history of the appearance and circulation of texts which carry accounts of experiences. The experiences are not separable from the people who encounter them nor from the texts in which accounts are transmitted.

Historical Consciousness within Progressive Knowledge

This historical awareness of the evolving human accounting for natural phenomena allows him to treat earlier findings within historically appropriate knowledge, while still using later developments to comment on, evaluate, or interpret the findings.[8] Typically, we see Priestley's historical awareness of the current state of knowledge in his discussion of Boyle's work: "We should now be surprised that any person should not have concluded *a priori*, that if an electric body attracted other bodies, it must, in return, be attracted by them, action and reaction being universally equal to one another. But it must be considered, that this axiom was not so well understood in Mr. Boyle's time, nor till it was afterwards explained in its full latitude by Sir Isaac Newton" (1:8).

He even includes material that was by his time considered in error, so as to make the account of communal experience complete. Although sometimes he labels the discredited results as delusions, elsewhere he presents them with no comment, and in other places as productive challenges. His account includes so many cases of at first implausible results later accepted as common knowledge that he is chary to exclude any result. Discredited theories are respected for their appropriateness to the state of knowledge in their times and their heuristic value for new discoveries.

Where results evoked controversy and troubled attempts at replication, he gives accounts of the processes by which the community came to pass judgment, as when J. A. Nollet travels to Italy to investigate claims about the medicinal effects of an electrical device and becomes "convinced that the accounts of cures had been much exaggerated" (1:187). Priestley then recounts other unsuccessful attempted replications, including some performed "in the presence of a great number of witnesses, many of them prejudiced in favour of the pretended discoveries; but they were all forced to be convinced of their futility, by the evidence of facts" (1:187). He comments, "After the publication of these accounts properly attested, every unprejudiced person was satisfied, that the pretended discoveries from Italy and Leipsick, which had raised the expectation of all electricians in Europe, had no foundation in fact" (1:188). Priestley describes judgment as being passed by the accumulated experience, which is recorded and circulated in a sequence of documents.

Specific Accounts and General Claims

In the attempt to represent fairly the experience and thinking of previous electricians, Priestley offers lengthy accounts, staying self-consciously close to the original presentations. Rarely is any publication given less than a full paragraph's discussion and often several pages are devoted to describing crucial findings. In both the preface and in passing he shows self-conscious awareness of the responsibilities and difficulties of accurate summary and he often quotes at length, sometimes for more than a page at a time. In the preface he comments "that I might not misrepresent any writer, I have generally given the reader his own words, or the plainest translation I could make of them" (1:x). And throughout he explains and justifies any liberties he takes with the text or the chronology.

Priestley's discussion of each electrician is built on specific empirical experiences or experiments which that individual was the first to notice or verify. These are recounted in sufficient detail for the particular event to be pictured, and in a number of cases to be replicated. Further, Priestley seems to have replicated many of the experiments he recounts. He explicitly notes the few cases when experiments present practical obstacles for replication, such as the need for unusual, costly, or sensitive apparatus.

A description of one of Francis Hauksbee's experiments is typically particular yet concise, relying as it does on the familiarity of typical apparatus and general procedures.

> Having tied threads round a wire hoop and brought it near to an excited globe or cylinder, he observed, that the threads kept a constant direction towards the center of the globe, or towards some point on the axis of the cylinder, in every position of the hoop; that this effect would continue for about four minutes after the whirling of the globe ceased, and that this effect was the same whether the wire was held above or under the glass; or whether the glass was placed with its axis parallel, or perpendicular to the horizon.
>
> He observed, that the threads pointing towards the center of the globe were attracted and repelled by a finger presented to them; that if the finger, or any other body, was brought very near the threads, they would be attracted; but if they were brought to the distance of about an inch, they would be repelled, the reason of which difference he would not seem to understand. (1:10)

Specific observations are the core of the account, but they are introduced and punctuated by discussion of experimental procedures and followed by a brief discussion. By such accounts of experiments Priestley makes available a vicarious experience of essentially all the significantly novel experiments performed by all electricians to that point in time and opens up the possibility of actual repetition of the experiments.

These accounts of experiences are not, however, presented as isolated events. Priestley organizes the experiments around general principles of electrical behavior. The Hauksbee experiment described above is preceded by statements classifying the experiment at two levels of generalization, with Priestley's italics emphasizing the significant general concepts: "I shall first relate the experiments [Hauksbee] made concerning *electrical attraction and repulsion*. . . . The most curious of his experiments concerning electrical attraction and repulsion are those which shew the direction in which these powers are exerted" (1:19–20).

Moreover, he presents series of experiments as coherent sequential investigations into particular phenomena, so that one experience seems to lead to the next according to the dictates of rational investigation. The Hauksbee experiments quoted above are immediately followed by further experiments to explore attraction and repulsion phenomena. This sense of a coherent program is extended beyond the work of individual researchers to be used as an organizing device for the work of many researchers. He imposes a rational shape to communal work, which by this gesture becomes a communal research program. Such generalizing coherence, naturally enough, appears at the head of chapters and sections, such as at the beginning of section 9: "Electricians, after observing the great quantity of electrical matter with which clouds are charged during a thunderstorm, began to attend to the lesser quantities of it which might be contained in the common state of the atmosphere, and the more usual effects of this great and general agent in nature" (1:421).

At times, the coherence of a communal program is identified through a fundamental problem being investigated, rather than through the phenomena discovered, as at the beginning of section 2: "One of the principal desiderata in the science of electricity is to ascertain wherein consists the distinction between those bodies which are conductors, and those which are non-conductors of the electrical fluid" (1:241). As we shall see in considering the later section on desiderata, the concept of research question is to Priestley an important device for organizing current work and helps project the discipline into the future. And even in this historical part, such open questions can be used to make sense of and evaluate work already accomplished. The opening of section 2 quoted just above continues:

> All that has been done relating to this question, till the present time, amounts to nothing more than observations, how near these two classes of bodies approach one another; and before the

> period of which I am now treating, these generalizations were few, general, and superficial. But I shall now present my reader with several very curious and accurate experiments, which, though they do not give us intire satisfaction with respect to the great desideratum above mentioned; yet throw some light on the subject. (1:241)

Overall the book presents a progressive historical account of increasing knowledge, organized around the accretion of general principles that give order to the accumulated experience. This textual structure does require some chronological adjustments and conceptual relabelings. Priestley admits his imposition of an after-the-fact logic on events, such as commenting that his accounts of Hauksbee's experiments are "related not exactly in the order in which he published them, but according to their connection. This method I have chosen, as best adapted to give the most distinct view of the whole" (1:19). Moreover, as mentioned previously, he makes connections between earlier observations and later-developed general principles. Although such anachronistic use of generalizations may offend modern historiography, it does give order to prior empirical experience and establish broad empirical grounding to current generalizations. By creating an account of all prior experiences using current generalizations, yet remaining close to the original experimental particulars, Priestley demonstrates the general force of his generalizations. In a late chapter, Priestley even goes back to examine ancient Roman accounts of phenomena that only since the time of Franklin could have been considered electrical. This procedure, later articulated by Pierre Duhem as "saving the phenomenon," ensures that the history of experience is not ignored when new concepts are developed. This is also the historical standpoint of contemporary reviews of the literature that use current concepts and research questions to make sense of the previous work in the field.[9]

Despite the organizing power Priestley finds in his contemporary concepts, he does not discard those experiences that do not fit under any concept or contradict current categories. To make room for anomalous and aconceptual material Priestley vigorously uses the category of *miscellaneous* both at the end of chapters and as full chapters, as in the "Miscellaneous Discoveries of Dr. Franklin and his Friends in America During the Same Period" and the final chapter of the historical section, "Miscellaneous Experiments and Discoveries Made Within This Period."

Because he believes in the power of anomalies to reveal new truths, he carefully notes them. In introducing his discussion of tourmalin he remarks, "This period of my history furnishes an entirely new subject of electrical inquiries; which, if properly pursued, may throw great light upon the most general properties of electricity. This is the *Tourmalin*: though, it must be acknowledged, the experiments which have hitherto been made upon this fossil stand like exceptions to all that was before known of the subject" (1:367).

Codification and Access to Ordered Experience

In the collection, representation, and codification of all recorded experience of electrical phenomena, Priestley has made accessible and given order to the communal empirical experience. By rescuing from obscurity early and unread work and showing that work consistent with following work and contemporary concepts, he draws a wider range of participants and experience into the cooperative effort of coming to terms with nature. Moreover, in making the previous work available, intelligible, and experienceable (vicariously or in actual practice) to his readers, he enriches each person's experience and provides a common base of experience and knowledge for all new participants in the field. All electricians will now know and have contact with essentially the same range of experience, with whatever local additions they might have access to or create themselves. With the history of the field available and codified, and all participants knowing the same thing, work may then proceed more rapidly, efficiently, and cooperatively. Throughout the history Priestley had noted as admonitory examples just those instances where lack of access, ignorance of previous work, or lack of shared assumptions led to duplication of effort or unnecessary conflict.

The shared history Priestley presents has not reached conceptual or empirical closure. He indicates the open questions, the anomalies, and the incompletely understood phenomena. In the preface he promises to provide updates on future research (as is provided in the second edition and as a separately published pamphlet). Last-minute prepublication addenda were also included in both first and second editions. The third edition had only limited revisions, for Priestley promised to write a *Continuation to the History*—a promise never fulfilled. Even more significantly, the latter half of the book points to an open-ended future by establishing the shared basis for continued work and offering practical guidance for further experiments. Priestley presents the extensive history of the first half as only a necessary prologue to the ongoing practice of knowledge creation.

General Propositions and Observable Knowledge: Part 2

The product of history, as Priestley tells it, is emergent principles which order the accumulated experiences. In part 2 of the book, Priestley abstracts these generalizations in a seven-page "series of propositions comprising all the general properties of electricity." These propositions describe the observable effects of electricity, rather than present ontological statements about the nature of electricity itself.

The propositions are largely cast in terms of generalized experimental events: for example, "It is the property of all kinds of electrics, that when they are rubbed by bodies differing from themselves (in roughness or smoothness chiefly) to attract light bodies of all kinds which are presented to them" (2:4). Accordingly many statements begin with "if" clauses to indicate the generalized experimental conditions that may be experienced by all observers. "If an electric shock, or strong spark pass through, or over the belly of a muscle, it forces it to contract as in a convulsion" (2:9). Even the occasional existential statement is elaborated in generalized operational experimental terms: "Electricity and lightning are, in all respects, the same thing. Every effect of lightning may be imitated by electricity, and every experiment in electricity may be made with lightning, brought down from the clouds, by means of insulated pointed rods of metal" (2:10).

The succinctness and generality of these claims is to Priestley a sign of the advance of knowledge: "For the more we know of any science, the greater number of particular propositions we are able to resolve into general ones" (2:2). Since these propositions are not a priori projections, but rather inductive generalizations, they compose an order created out of accumulated experience. The ability to find encompassing propositions of increasing generality indicates understanding of more powerful and fundamental principles of phenomena.

Nonetheless, the propositions presented by Priestley, although generally following a sequential expository order, are not tightly organized around a single account of the nature of electricity, although such an account might have led to even greater succinctness, as Priestley notes (2:2). They are largely disjunct statements about separately observable phenomena, with only a few logical connectives. Priestley is very careful to distinguish these general propositions which may be separately observable by all electricians from any coherent account of what electricity might be, for in his time that was only a matter of theoretical speculation about unobservable matters.

By establishing a succinct codification of what is currently known, generally agreed to, and observable, Priestley clarifies the extent of shared knowledge. This brief, yet comprehensive, list allows for coordination of continuing work, recognition of novelties and anomalies in new observations, rapid socialization of neophyte electricians into the current state of knowledge, and easy reference. The list of propositions thus serves the functions of both the modern handbook and the modern textbook. Furthermore, by separating those statements which are generally agreed to be empirical truths from uncertain theories, Priestley allows for a differentiation of discussion in ensuing work. He does not propose a unitary system of knowledge, as Newton does where general theory appears inseparable from representation of empirical experiences, so that the theorizing is made invisible and denied (see Bazerman, chap. 4). Rather he establishes agreement on the level at which all can agree and focuses debate on less certain matters. Thus he not only codifies the existing knowledge, but codifies the levels and manners of discussion. He provides literary technology first for coordination of areas of agreement by slowing down the communal ascent up the ladder of generalization (as Bacon cautions the individual researcher to do) and second for domestication of conflict by limiting the arena of disagreement.

Historicizing Theory: Part 3

Having historicized experience and discovery in the early parts of his work, Priestley historicizes theory in the third part. Theories, as Priestley presents them, historically precede knowledge. Theories, which he uses interchangeably with hypotheses, help frame experiments and lead to newly observed phenomena, but they themselves are not substantiated knowledge. When the hypothesized phenomenon is made observable through experiment, it passes out of the realm of theory into the realm of operational knowledge. As Priestley states in his introductory comments to part 3:

> Hypotheses . . . lead persons to try a variety of experiments, in order to ascertain them. In these experiments, new facts generally arise. These new facts serve to correct the hypothesis which gave occasion to them. The theory, thus corrected, serves to discover more new facts, which, as before, bring the theory still nearer to the truth. In this progressive state, or method of approximation, things continue; till, by degrees, we may hope that we shall have discovered all the facts, and have formed a perfect theory of them. By this perfect theory, I mean a system of propositions, accurately defining all the circumstances of every appearance, the separate effect of each circumstance, and the manner of its operation. (2:15–16)

At the end of investigation, then, theory changes from a conjecture about causes to an empirically based operational account.

Theories, then, are useful but uncertain and historically bounded accounts. They are heuristic. Discussion of theories leads to difficulties only because investigators present their hypotheses as general truths and become too attached to them. Thus they do not allow the replacement or modification of theory in relation to new findings, nor do they admit new hypotheses that would serve as heuristic for new discoveries. Priestley found this attachment to speculative theories particularly rife within electricity because, "As the agent is invisible, every philosopher is at liberty to make it whatever he pleases, and to ascribe to it such properties and powers as are most convenient for his purpose" (2:16).

In his own account of electrical theory, Priestley adopts several literary methods to identify the limited and transient utility of theories and to decrease his own and the reader's attachment to any particular theory. He describes the historical state of knowledge out of which each theory arises and which it is meant to account for, identifies the new findings that the theory led to, and finally presents the empirical results the theory could not adequately account for. Unlike the timeless presentation of general propositions, theories are given a specific time and place. Moreover, Priestley casts theories aside after they have played their role in the generation of empirical truths and have been made obsolete by further discoveries.

Priestley adopts this historical attitude even to theories viable in his own time, including his favored account: Franklin's theory of positive and negative electricity. Priestley discusses how Franklin's theory provides a satisfactory account of a number of phenomena, especially that of the Leyden jar—the phenomenon which the theory was first developed to explain. But he also discusses a number of phenomena for which the theory remains inadequate, such as the influence of points and the electrification of clouds. Moreover, he points out that the theory is in a state of flux, being subject to modification by a number of electricians. On the other hand, he finds that the ability of this theory to incorporate findings and ideas from previous theory very much in its favor, as it does not abandon collective experience. Finally, although Priestley ends this chapter with a panegyric to Franklin, the quality he praises most is Franklin's diffidence about his own theory and his just "sense of the nature, use and importance of hypotheses" (2:39), which attributes more importance to the facts produced than the general accounts.

The most significant feature of Priestley's presentation of theories is that the chapter on his favored theory is followed by an almost equally long chapter on a contending theory to which he also attributes great utility. Priestley comments, "I shall, notwithstanding the preference I have given to Dr. Franklin's theory, endeavour to represent [the theory of two electrical fluids] to as much advantage as possible, and even to do it more justice than has yet been done to it, even by Mr. Symmer himself" (2:41). After an extensive summary of the theory he points out certain phenomena for which this theory appears useful and plausible, in some instances providing less-tortured accounts than Franklin's single-fluid theory. Like Franklin's theory, Robert Symmer's theory offers no inconsistency, but lacks insight into certain phenomena. Priestley then modifies the theory to answer the chief objection made to it and comes to the conclusion that the theory is consistent with all available evidence. Priestley cites another electrician, Cigna, granting Franklin's theory the upper hand because of its overall greater simplicity, but no final strong judgments are made. The section ends with Priestley inviting readers to communicate "any other theory, not obviously contradicted by facts" (2:52).

Thus even while maintaining a favored theory, Priestley manages to distance himself from it and develop a dispassionate method for discussing and evaluating competing theories. Not only does his tone and literary method allow for modification and theory change, it separates the advocacy of theory from the discovery of facts, even while recognizing the dialectical connection between fact and theory. His mode of discussion diffuses the argumentative gap that results from theory differences, allows cooperative research on the level of general propositions, and offers an orderly procedure for discussing and evaluating theories. He offers a means for communal theory development and modification short of total replacement. Finally, by reducing the status of theory, he reduces the stakes in theory wars.

"A Great Deal Still Remains to be Done": Part 4

To Priestley, the codification (or gathering together and conceptual organization) of prior work only served to highlight the incompleteness of our communal electrical knowledge. In the first three parts – the history, the general propositions, and the theory – he is at pains to point out what issues are left open, what is unknown, what is puzzling. One of the great dangers he finds in the individual's adherence to a single theory is that the individual may feel that electricity has been solved and therefore find little motivation to extend researches. Such is his accusation against Nollet (2:25). Systematic codification, to the contrary, identifies specific areas needing investigation and unsolved research problems (or desiderata, as Priestley calls them).

To make these incompletenesses even more visible, and therefore to guide future work, Priestley gathers them together in the middle chapters of section 4, in the form of "queries and hints," following on the exhortation to continuing research of the opening chapter. These queries and hints are presented as lists of questions. Questions, even while they invite unknown answers, constrain the form of the answers. A series of questions can set an agenda for communal work and provide a framework for comparing competing answers.

Priestley's questions are set under various headings corresponding to phenomena identified and elaborated in the previous work. Under each heading, the opening questions tend to be the more fundamental questions, which are then elaborated more specifically in the following questions. For example, the "Queries and Hints Concerning Excitation" begins with a fundamental question of structure, moves to elaborating phenomena, and then specific experiments:

> What is the difference, in the eternal structure of electrics, that makes some of them excitable by friction, and others by heating and cooling?
>
> What have friction, heating, cooling, and the separation after close contact in common to them all? How do any of them contribute to excitation? And in what manner is one, or the other electricity produced by rubbers and electrics of different surfaces?
>
> Is not Mr. Aepinus's experiments of pressing two flat pieces of glass together, when one of them contracts a positive and the other a negative electricity, similar to the experiments of Mr. Wilcke concerning . . . ?

By explicitly mentioning recent and ongoing work in relation to open questions, Priestley identifies common problems that can draw researchers into a common endeavor and sets an example of public discussion of unresolved work. Rather than leaving the workshop of the various researchers closed until the individuals are ready to present a claim substantiated by a public demonstration of a successful experiment, he invites the entire community to share in open discussion, drawing hints from each other. Furthermore, he invites others to present their open questions, for

> Many persons can throw out hints, who have not leisure, or a proper apparatus for pursuing them: others have leisure, and a proper apparatus for making experiments, but are content with amusing themselves and their friends in diversifying the old appearances, for want of hints and views for finding new ones. By this means, therefore, every man might make the best use of

> his abilities for the common good. Some might strike out lights, and others pursue them; and philosophers might not only enjoy the pleasure of reflecting upon their own discoveries; but also upon the share they had contributed to the discoveries of others. (2:60–61)

Publicly shared questions help coordinate the work of many hands and help further the incomplete ideas of many minds. As that work goes forward, questions are answered, discarded, or change. Questions, like theories, are historically bounded. Priestley comments that his questions may likely soon appear "idle, frivolous, or extravagent" (2:58), and he makes a number of emendations in the second and third editions, eliminating some questions and adding new ones. He clearly has the idea of a moving research front composed of evolving problems, and he wishes to establish a textual means of communally articulating the current state of questions.[10]

To Priestley, the advancement of electrical knowledge also depended on coordination with other forms of knowledge which bear on the investigations. The closing section of part 4 discusses the other branches of knowledge which electricians ought to become familiar with: in particular the studies of chemistry, light and colors, atmosphere, anatomy, mathematics, mechanics, and perspective. His inclusion of mechanics and perspective recognizes that research is an empirical and social practice. The philosopher who wishes to explore new phenomena must be able to construct new philosophical machines, and the philosopher who wishes to share his findings by publication must be able to draw precisely.

Mechanical Coordination: Part 5

Since Priestley recognized that the advance of electrical knowledge was dependent on the advance of machines, he felt the need to engage electricians in mechanical construction. In the historical first part of the book he often pointed out the importance of machinery to specific discoveries. Here in the fifth part he summarizes the historical progress of machinery to codify and coordinate the state of the art. Machines provide the originators with access to new phenomena, but even more they provide the entire community of electricians access, for reproduction of machines allows reproduction of phenomena. Shared machinery makes possible shared experiences and cooperative investigation of the phenomena generated and displayed by the apparatus. Moreover, to maximize communal development the best machinery and principles of construction should be made available. Finally, to coordinate work, you must coordinate apparatus, so that investigators are making claims concerning the same things.

Therefore, explanations of the principles of the machines and specific guidelines for the construction of the most effective machines are important to a coordinated experimental science. Priestley devotes about twenty pages to the description of guidelines for the construction of electrostatic generators, metallic points, batteries of Leyden Phials, and electrometers. Just as there are open questions about electrical phenomena, there are open questions about the optimum designs: for example, "It has not yet been determined by electricians what kind of glass is the most fittest for electrical purposes" (2:91). He then devotes another dozen pages to discussing the advantages and disadvantages of particular machines developed and used by various investigators. The mechanical descriptions are supported by illustrations.

As indicated by an advertisement accompanying the *Familiar History* of 1768, Priestley himself engaged in the construction and distribution of electrical machines. (For further discussion of the importance of mechanical practice in Priestley's work, see Schaffer.)

The Increase of Empirical Experience: Parts 6 and 7

Access to machines does not guarantee successful, copious, and progressive results. People must use those machines and use them correctly. Experience has been the traditional teacher of successful experimental practice, but in parts 6 and 7, Priestley aims to expedite successful experience for neophytes, so that they will produce more results more rapidly.

Part 6 is devoted to "Practical Maxims for the Use of Electricians," describing the craft knowledge that Priestley has gained through his own experience. He hopes to make the path of young electricians less arduous, for "it is in the interest of science in general, that everything be made as easy and inviting as possible to beginners. It is this circumstance only that can increase the number of electricians, and it is from the increase of this number that we may most reasonably expect improvements in the science" (2:119). What follow are fifteen pages of homely craft advice and warnings, such as "A little bees wax drawn over the surface of a tube will greatly increase its power" (2:120). And "let no person imagine that, because he can handle the wires of a large battery without feeling any thing, that therefore he may safely touch the outside coating with one hand, while the other is upon them. I have more than once received shocks that I should not like to receive again" (2:132). Such advice currently is conveyed in laboratory manuals and other training documents. But as Collins forcefully argues, much craft knowledge remains inarticulate and certainly unpublished, so it is learned, if at all, directly over the laboratory bench.

In this same spirit of introducing neophytes into experimentation and ultimately increasing the communal experience, Priestley offers in part 7 directions for performing "The Most Entertaining Experiments Performed by Electricity." He opens this part with an enthusiastic account of the delights and wonders of simple experiments: "What can seem more miraculous than to find, that a common glass phial or jar, should, after a little preparation (which, however, leaves no visible effect, whereby it could be distinguished from other phials or jars) be capable of giving a person such a violent sensation, as nothing else in nature can give . . . and this shock attended with an explosion like thunder, and a flash like that of lightning?" (2:135). Moreover, he encourages would-be experimenters by suggesting that these effects, although entertaining, are far from trivial: "So imperfectly are these strange appearances understood, that philosophers themselves cannot be too well acquainted with them. . . . It is possible that, in the most common appearances, some circumstance or other, which had not been attended to, may strike them; and that from thence light may be reflected upon many other electrical appearances" (2:136).

Thirty pages of detailed instructions follow on how to carry out experiments involving explosions, shocks, flashes of light, ringing bells, dancing dolls, puppets with hair standing on end, and gunpowder. They are all described with much enthusiasm for their amusing qualities. Such descriptions now are reserved for children's introductions into experimental sciences of the "Scientific Tricks You Can Do" genre, with much of the same motivation: recruitment of the young into science. Priestley well understood that no communal research program will prosper without the personnel to carry it forward.

Extending Knowledge: Part 8

In the last part of the book Priestley presents his own experiments, developed out of his replications of experiments in the literature. In a sense he presents himself as the ideal reader of his account of the history and present state of electricity, using the text as a foundation for new activity.[11] Moreover, he presents his new work as an example of the dynamics of knowledge, that the history of natural philosophy is open-ended and that new work proceeds out of old. This message of continuing, coordinated work outweighs the specific findings that Priestley presents; he comments that his method of presentation is "less calculated to do an author honour as a philosopher; it will, probably, contribute more to make other persons philosophers, which is a thing of much more consequence to the public" (2:165).

Priestley's new experiments are arranged according to topics first raised in the historical chapters. Moreover, he continually refers to the literature and private correspondence with other electricians. He opens sequences of experiments with comments such as he found certain of Beccaria's experiments not quite adequate (2:232), or that he had certain doubts about an aspect of Franklin's theory (2:184), or that there was a matter of dispute among electricians (2:201). Similarly he indicates obtaining materials (e.g., 2:308) and ideas for experiments from other electricians (e.g., 2:187). In addition, he reports corresponding with them about procedures (e.g., 2:179). Finally, he compares his results with those of others (e.g., 2:273–76). In such repeated cross-reference to the work of others he follows modern practice rather than the practice of his contemporaries.

Yet, although he embeds his accounts in the literature and indicates his constant interaction with the rest of the community, he does not present his work as necessarily occupying a fixed or stable place in the literature, as is often the case in modern articles, where one uses the literature as a matrix around the new claim to assert its centrality, meaning, and solidity (see Swales and Najjar; Dudley-Evans). Priestley presents his work as part of an ongoing and unsettled process. The starting place in the literature does not fix where the investigation ends up nor is the opening hypothesis (derived from the literature or by analogy with other reported phenomena) necessarily the final one confirmed or denied. He presents his research as a mode of dialectical discovery which sometimes ends in a strong claim, but more often does not. Sequences of experiments are left off with unresolved questions or invitations to others to continue the work.

Priestley called this discovery path form of presentation an analytical argument and believed it was more deeply persuasive than the prooflike argument which supports a claim asserted at the opening of the essay, which he called the synthetic argument. In analysis you could carry your reasonable audience down the same path of experience and reasoning that led you to your conclusions rather than coercing belief through a constraining set of arguments. Intellectual coordination would come from a more complete sharing of the research experience (2:166–67; see also Priestley, *Lectures on Oratory*; Moran; Lawson).

Additionally, he felt that this analytical method would aid others in their investigations by indicating all the false leads and mistakes. Others could avoid these mistakes, find meanings in details that did not seem so significant to the original investigator, and take advantage of the full range of thinking. Moreover, such naturalistic accounts would demystify the research process for neophytes so that they would be less intimidated to take up their own researches.[12] He, in fact, criticizes Newton for hiding his thinking process, with the result that we hold the man too greatly in awe to follow in his footsteps:

> If a man ascend to the top of a building by the help of a common ladder, but cut away most of the steps after he has done with them, leaving only every ninth or tenth step; the view of the ladder, in the condition in which he has been pleased to exhibit it, gives us a prodigious, but an unjust idea of the man who could have made use of it. But if he had intended that any body should follow him, he should have left the ladder as he constructed it, or perhaps as he found it, for it might have been a mere accident that threw it in his way. (2:167–68)

Priestley's ladders, as presented in over two hundred pages, are many, but few get far off the ground. He presents the different lines of investigation sometimes as having strict logical direction, with each hypothesis or problem suggesting a new experiment and the results suggesting a new problem or hypothesis. Yet he rarely concludes in any statement of great certainty or generality. At other times the sequencing of experiments seems weaker as accidental observations set the sequence in motion with no strong direction. Priestley ends such sequences just by varying the experiment to see if he can find any leads. In this vein, he comments at the beginning of the sequence of experiments on circular spots:

> In the courses of experiments with which I shall present the reader in this and the following two sections, I can pretend to no sort of merit. I was unavoidably led to them in the use of a very great force of electricity. The first appearance was, in all the cases, perfectly accidental, and engaged me to pursue the train; and the results are so far from favouring any particular theory or hypothesis of my own, that I cannot perfectly reconcile many of the various phenomena of any hypothesis. (2:260)

This sharing of wide-ranging, but imperfectly accounted for, experience leads to a diffuse presentation, where few forests emerge from many trees. Priestley here does not even have the ordering potential of retrospective categories, as he did in the historical account. As I have noted elsewhere (Bazerman, chap. 3), this kind of discovery account gained popularity in *Philosophical Transactions* at just about this time (possibly led by Priestley's enthusiasm for it), but it did not last until the turn of that century. Although it allows for sharing of open-ended work and recognition that the truths of natural phenomena cannot be directly and self-evidently read from individual experiments, it seems to have been too equivocal in its message for the codification necessary for the coordination of continuing work. A century earlier Newton had also used a discovery narrative in his "New Theory of Light and Colours," but he had found it insufficiently persuasive to forestall serious controversy. In order to compell assent he developed the prooflike form of argument which Priestley criticized him for (Bazerman, chap. 4).

Modern scientific articles have found a solution for codifying the research which combines compelling assertion in the fashion of Newton with a recognition of the evolving character of the literature and the communal investigation in the fashion of Priestley. By asserting claims within a constructed matrix of the literature, modern articles attempt a kind of rolling codification. They typically pretend their claims are already accepted and integrated into a literature reconstructed in the article introduction (see Berkenkotter, Huckin, and Ackerman, chapter 8 of this volume). The body of the argument then appears to act as an irrefutable inductive proof, although the value and meaning of both the literature and the current investigation may be far from settled within the knowledge-validating research community. In this manner, each new article takes part in the sorting out of knowledge claims even as they are proposed.[13]

Conclusion: The Dilemma of Large Cooperative Endeavors

In forging a way of talking about science that would coordinate the work and experience of many, while not holding them accountable to any a priori or individually conceived theory, Priestley was attempting to create a broad-based science open to all who wished to respect and extend the common experience. This project was founded on his radical theological, philosophical, and political beliefs. He believed democratic participation and open-ended negotiation of phenomena would lead to discovering the true accounts of nature, encompassing the experience of all humankind. He understood that such an endeavor must be coordinated on many levels, from experimental findings to machine construction to research problems. But he desired that codification emerge only from the shared wisdom, experience, and responsible negotiation of humanity, excluding none of the verifiable variety of life. His well-worked-out philosophy and sociology of science relied on his developing an appropriate rhetoric of science that would facilitate cooperation and coordination of current communal empirical investigation while respecting the experience embodied in the history of science.

Priestley was partly successful in creating rhetorical means to assert codification yet still to keep the door open to the full range of experience. To avoid the cultural amnesia of codification of history, Priestley stays close to the literature, which he attempts to reproduce with some historical sensitivity and copious detail, even where it does not fit into his contemporary categories. Codifications of present activities of theorizing, experimenting, and machine construction, Priestley treats as useful but temporary accounts, to be rewritten as events progress. Codifying the future, however, is trickier; it can shut down the open-ended processes of experience and discovery by enforcing a closed system of bureaucratic definition of what can and should be done. Yet not codifying the future strongly enough leads to an uncoordinated proliferation of actions of little meaning—an open end that unties the threads of the past drawn together in the present moment. This is a rhetorical problem that Priestley had not yet solved, although many of his rhetorical techniques for dealing with past, present, and future have been used in scientific writing since his time.

Perhaps the most important consequence of the rhetorical dynamics put in motion by Priestley is a form of discourse directed at an inward-facing community concerned with shared research problems and developing a communal experience. He creates textual means for researchers to look toward each other to create a common knowledge. In support of this prototype discipline, Priestley also offers textual means of recruiting and socializing new participants into the communal project.

What Priestley perhaps undervalues, however, are individual assertion and competition within the coordinated communal activity. In eschewing individual glory in the name of the communal advance, in letting all into his unsettled workshop, and in refusing to pretend to certainty in the face of historical flux, Priestley has inadequately allowed for the hypothesizing force of science that has allowed individuals to assert bold leaps of knowledge and then to await to see if the world lives up to their educated intuitions. Priestley creates a machinery for benign cooperation, but that machine also has seemed to need the drive of agonistic struggle, to help force claims up the ladder of generalization and power. Despite Priestley's amiable sociability, science has maintained an important role for aggressive assertion of theories, embattled competition, and Nobel Prizes. In fact, these have become part of science's sociability.

Nonetheless, the coordinating mechanisms of the kind Priestley advances are precisely what make the agonism more than a war of all against all. These mechanisms have given order to the accumulating corporate experience and have provided common assumptions, comparable terms, and similar empirical procedures with which to advance the shared work. Priestleyian codification has created an evolving and contingent—but at any moment predominantly stable and communally recognizable—playing field, upon which focused and fruitful struggle can take place.[14]

NOTES

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1. Rachel Laudan's current investigation of early histories of science may reveal more about the textual tradition out of which Priestley was writing (private communication).

2. J. L. Heilbron's standard modern history of electricity to 1800 affords fewer than sixty pages to seventeenth-century developments, but devotes about one hundred and eighty pages to the two-thirds of the eighteenth century that preceded Priestley's publication.

3. Unexplored in this essay is how Priestley's vision of history and the historical progress of knowledge fits in with developing enlightenment attitudes toward history and the accumulated wisdom of the human race. Encyclopedism in its direct French and modified British forms are of course relevant here. Also unexplored are the roots of Priestley's ideas of cooperative communities, which may have their foundations in radical Puritanism of the seventeenth century.

4. Priestley's psychology is explicitly Hartleyian associationist in both *A Course of Lectures on Oratory and Criticism* and *The History and Present State of Electricity*. See also the introduction to the modern edition of the former by Vincent Bevilacqua and Richard Murphy. In light of Priestley's view of empirical natural philosophy it is important to emphasize the role Priestley sees for experiences in forming associations. Associations are for him not just arbitrary connections among mental representations. Progress (and thereby fulfillment of the divine plan) comes for Priestley from the incorporation of empirical experience of the world into the set of mental associations and the readjustment of those associations so as to be harmonious with and useful for the ordering of the experience. Increasing empirical experience becomes, for him, a moral duty. This is a curious theological variant on Fleck's observation that modern science is characterized by the active pursuit of passive constraints.

5. Laboucheix reconciles Priestley's radical politics and progressivism with his theological and physical determinism by examining Priestley's dynamic view of materialism, necessity, and decision making, which creates the opportunity for human intelligence to understand and abstract the laws of nature, so that humans may accommodate themselves and live in harmony with those principles that determine their existence.

6. Priestley, by associating natural philosophy with a life of action to be pursued by males in fulfillment of a divine plan and then by framing the study of natural philosophy within a corresponding male educational system, furthers the gender-coding of human action in Western culture. There are consequences here for genderization of rhetoric as well as the more general genderization of society, but both these issues must remain beyond the scope of this essay. I would, however, point out that the cooperative technology fostered by Priestley differs significantly from the forms of cooperation involving acquiescence and subordination often stereotypically gender-coded as female. Priestly also notes certain characterological correlates of the philosophic activity he promotes for men: "Nor is the cultivation of piety useful to us only as men, it is even more useful to us as philosophers: and as true philosophy tends to promote piety, so a generous and manly piety is reciprocally, subservient to the purposes of philosophy" (*History of Electricity* 1:xxiv).

7. Page references throughout will be to the third edition of 1775 (in two octavo volumes), which is available in a modern reproduction (New York: Johnson Reprint, 1966), instead of the first edition of 1767 (a single-quarto volume), available only in the original. The texts of the two editions (and the intermediate second, 1769) are in most details the same, except for updated information, presented largely through whole paragraph insertions describing more recent work and a few deletions of research questions which have been superseded. The later fourth (1775) and fifth editions (1794) follow the third in all respects. A French translation in three volumes (1771) follows the first edition, and a single-volume German translation follows the second.

8. Hoecker examines in greater depth the tension between Priestley's historical sensitivity and his progressive vision of divinely inspired historical development.

9. However, Priestley's history does differ from modern reviews of the literature in its comprehensiveness of coverage, historical extensiveness, and detail of reportage. In part this may be because modern findings usually occur within highly codified systems of knowledge, practice, and questions. Thus new findings usually come presorted into categories, as elaborated in introductory review sections; only novel, unexpected, or anomalous work stands out and calls for attention. Otherwise most findings simply confirm or elaborate the already codified system. Reviews of literature necessarily focus on those unusual details that raise questions, and are selective about the many reports that only add "more gory details." Only revolutionary new claims need to go back to examine the entire file of gory details to reinterpret them consistent with the novel concepts and new questions, and even the reinter-

pretation may be carried on through translation of large groups of material under general headings. Priestley, on the other hand, was creating the codification which made sense of the extensive history. He was first putting the material into conceptual categories, although the concepts had been emerging through the entire period he examines. On the modern review article, see Myers, chapter 2 of this volume.

10. In listing questions he varies a practice used a century earlier in the early *Philosophical Transactions* and then early in the century by Newton in the *Opticks*. In the early *Philosophical Transactions*, however, these questions were aimed at gaining specific data from world travellers who could report back on life forms, geologic and astronomical phenomena, and cultural knowledge from far corners of the earth. The list of questions for travellers were not set as research problems so much as specific informational requests. The respondents were asked to cooperate in providing useful information, but they were not invited to participate in a research front. Newton, on the other hand, used his queries as ways of asserting his beliefs on topics about which he thought he had certain answers but about which he did not have compelling arguments. To Newton there was no research front, only settled issues, imperfectly proven. The questions are often in the coercive form of "Is it not true that . . ." The form of cooperation he sought (and often obtained among the Newtonians) was acquiescence to his suggestions. Priestley here, however, phrases his questions as genuinely open invitations to cooperative investigation.

11. The process of writing the book was indeed his apprenticeship into the community of electricians, introducing him to the literature, machines, experiments, and active investigators. For a discussion of the relation between reading, activity, and writing in the formation of working scientists' knowledge and plans, see Bazerman, chap. 8.

12. In this impulse he anticipates Medawar by two centuries.

13. Huckin has noticed in some fields an increased emphasis on the news-value of articles, at the expense of the empirical argument. This carries the sometimes useful fiction of rolling codification one step further. If the pretended codification leads the actual evaluation by too great a distance, however, consequences may go beyond problems in examining the claims of each article to a disorganization of the communal knowledge which allows coordination of work.

14. In Fujimura's terms, by creating means to allow alignment of disciplinary and individual work, Priestley has made possible the identification of doable problems within modern science, against which the individual may assess his or her own resources.

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