12 WRITING WELL, SCIENTIFICALLY AND RHETORICALLY

PRACTICAL CONSEQUENCES FOR WRITERS OF SCIENCE AND THEIR TEACHERS

The forms of writing are historical phenomena—created, recognized, mobilized, and given force within the mind of each writer and reader at specific social-historical moments, but transmitted in the accumulation of texts. Accumulated, socially contexted, textual experience increases the formal repertoire and procedural command of each writer and reader. This book has explored the changing repertoire within the domain of scientific writing and the social, empirical, and epistemological consequences of that repertoire in use within changing contexts.

The repertoire has grown and changed as individuals have confronted specific rhetorical problems within specific rhetorical situations. In adopting the role of scientist, individuals commit themselves to creating novel claims persuasive to other scientists knowledgeable and experienced in their specialty. They must draw on their reading, their empirical experience, and their interactions with their peers so as to use the existing symbol system to point to phenomena previously uncontained by symbols but reliably reproducible, recognizable, and persuasive to peers. In cases presented here and elsewhere in the literature on the rhetoric of science, we have seen individuals use, transform, and invent tools and tricks of the symbolic trade.

Genre as a Sociopsychological Category

Some of these tools and tricks have proven so useful and forceful as to become regularized and even institutionalized mandatory features (both formal and procedural) of particular types of scientific communication. What we recognize as the genre of the experimental article embodies many such regularized formal and procedural elements. Genre, then, is not simply a linguistic category defined by a structured arrangement of textual features. Genre is a sociopsychological category which we use to recognize and construct typified actions within typified situations. It is a way of creating order in the ever-fluid symbolic world.

The textual features we may associate with any particular genre have no necessarily fixed definition. Even attempts to hold features firm by social processes of institutionalization lead only to a temporary stability; despite the great influence of the APA *Publication Manual,* a quick scan of psychology journals in 1987 will reveal a wide range of rhetorical innovation, hardly contained within the bounds of the idealized model (chapter 9). Nor are the textual features that we associate with a genre all of the same order. Some are large organizational features, such as the presentation of method after the introduction and before results in many versions of the experimental article. Others are associated with citation practices (both in terms of citation format and quantity and in terms of the role of citation within the argument). Others are matters of quantity and location of detail. Still others have to do with the level, function, and placement of generalization. The use or absence of transitions also characterizes the genre at different moments in different disciplines—and so on, through all the myriad kinds of features discussed in the previous chapters.

Most important, the features we may associate with genre are hardly contained in their formal appearances on the page. The formal features are only ways more fundamental relations and interactions are realized in the act of communication. In recognizing and using genre, we are mobilizing multidimensional clusters of our understanding of the situation, our goals, and our activity. Some of these relational themes we have seen expressed at various times within the genre of experimental article have to do with the agonistic structure of discussion within journal forums, the desire to compel assent, the emergence of a domain of general claims separate from a domain of specific claims, the attempt to construct empirical experience through experimental intervention into nature and to represent that experience, the enactment of the emerging role of scientist within a changing structure of the community, the mutu-

al construction of a shared knowledge within the community, and the changing relations with communities involved in more applied endeavors. These relations are played out on social, psychological, empirical, epistemological, as well as textual gameboards. Understanding the genre one is working in is understanding decorum in the most fundamental sense—what stance and attitude is appropriate given the world one is engaged in at that moment.

Because genre is such a multidimensional, fluid category that only gains meaning through its use as an interpretive, constructive tool, the reduction of any genre to a few formal items that must be followed for the sake of propriety (decorum in its most restricted sense) misses the life that is embodied in the generically shaped moment. As writers, we find a list of formal requirements of any particular genre gives us only weak command over what we are doing and gives us no choice in mastering or transforming the moment. As teachers, if we provide our students with only the formal trappings of the genres they need to work in, we offer them nothing more than unreflecting slavery to current practice and no means to ride the change that inevitably will come in the forty to fifty years they will practice their professions. We do better to grant ourselves and our students means to understand the forms of life embodied in current symbolic practice, to evaluate the consequences of the received rhetoric, and to attempt to transform our rhetorical world when such transformation appears advisable.

Rhetorical Self-Consciousness and the Invention of Science

Sometimes individuals who have significantly transformed scientific writing have had some degree of rhetorical self-consciousness, as we have seen in the cases of Newton and Oldenburg. Elsewhere individuals seem to veil their rhetorical awareness behind other sets of beliefs, as in mid-twentieth-century experimental psychology. There rhetoric is denied even as it is practiced, because the practitioners feel they have no other alternative; as I have heard a number of experimental psychologists say in response to my chapter on the writing of their field, "the practices you describe are not rhetoric; they are simply good science." And some individuals with little self-consciousness about their formulating practices just keep doing what seems demanded by the situation, what is rewarded by persuasive success, as seems to be the case of many of the contributors to the early *Philosophical*

Transactions. When elaborate practices are deeply embedded in the training and socialization of scientists, as among twentieth-century physicists, innovations in symbolic process are likely not to be perceived as either rhetorical or innovations, but rather just as continuing business as usual.

No matter the degree of self-consciousness accompanying the innovations and emergence of regularized procedures, these transformations of rhetorical practice matter. They matter significantly, for they create the symbolic ground on which scientific formulation and argument occur and they shape the communal action and the structured interaction of the scientific community. The regularized symbolic practices define the symbolic universe within which the community operates; and the degrees and kinds of restrictiveness within these practices define the directions and dynamics of growth for the knowledge to be produced by the field. As we have seen, the symbolic practices even deeply influence the empirical experience of individuals and the identification of communally reconstitutable phenomena.

The tools and tricks of the symbolic trade are what make possible an empirical science that uses symbols to formulate knowledge about natural phenomena. The various cases studied here all reveal a history of symbolic practices defining phenomena of substantive and evidentiary interest, then drawing closer to the phenomena within the stylized communication of the research community, driven by the difficulties of persuading motivatedly agonistic peers. Persuasion is at the heart of science, not at the unrespectable fringe. An intelligent rhetoric practiced within a serious, experienced, knowledgeable, committed research community is a serious method of truth seeking. The most serious scientific communication is not that which disowns persuasion, but which persuades in the deepest, most compelling manner, thereby sweeping aside more superficial arguments. Science has developed tools and tricks that make nature the strongest ally of persuasive argument, even while casting aside some of the more familiar and ancient tools and tricks of rhetoric as being only superficially and temporarily persuasive.

Scientific Writing and the Rhetorical Tradition

Skill in scientific writing, as with most human arts, is knowing what you are doing and making intelligent choices. This is hardly a startling pronouncement and firmly within the rhetorical tradi-

tion. Classical rhetoric is an art of oral performance built on the analysis of the kinds of rhetorical situations, goals, and tools that resided within the legal and political world of ancient Greece and Rome.[1] The basic goals of the study of political and scientific language, as of all language uses, share a fundamental concern: to understand and control the symbolic actions in order to achieve desired communal ends.[2] But the rhetorical situations, goals, and tools of contemporary journal science are quite different from those of the Athenian agora, and as the symbolic means for science developed they were consistently distinguished from arts of political oratory identified as Rhetoric. Quite appropriately the two forms of symbolic art developed different conceptual vocabularies and analyses. However, in the search for certainty of statement and compellingness of argument, the constructed, socially active character of the scientific symbolic system seemed to be forgotten. Scientific language began to seem an escape from language, and thus not a matter for conscious control. Propriety and clarity, not letting errors of language get in the way, were all the scientific writer needed to worry about. Where this book diverges from tradition is only in explicitly recognizing that scientific language is of our own making and used only in human, social contexts; therefore it is a matter for our conscious control.[3] And the levels of our conscious control can extend as deeply as we can come to understand the communication process.

The historical overt disavowal of the socially active, rhetorical character of scientific use of language did not, however, mean that individual writers confronting blank pages to be filled and filled pages to be read did not implicitly have an understanding of what written texts could do. They expressed various kinds of conscious and unconscious practical control over their language and the complex practices in which the language was embedded. The detailed analyses of the preceding chapters

1. George A. Kennedy has written the standard surveys of classical rhetoric: *The Art of Persuasion in Greece, The Art of Rhetoric in the Roman World: 300 B.C.-A.D. 300,* and *Classical Rhetoric and Its Christian and Secular Tradition from Ancient to Modern Times.* Useful introductions to the field are also provided by James J. Murphy, ed., *A Synoptic History of Classical Rhetoric* and Winifred B. Horner, ed., *The Present State of Scholarship in Historical and Contemporary Rhetoric.*

2. In composition and the teaching of writing, research and theory have recently turned toward an examination of the social bases of writing, thereby coming closer to the concerns of classical rhetoric in understanding statement making as a socially embedded form of social action. See, for example, Bizzell; Cooper; Ede; Faigley; Herrington; LeFevre; North; Nystrand; Odell and Goswami; Perelman; Rubin and Rafoth.

3. In the last decade within the discipline of rhetoric some limited attempts have been made to address the rhetorical character of scientific writing. See, for example, Fahnestock; Halloran; Overington; Weimer.

serve exactly to make explicit the complex rhetorical concerns embedded within the emerging practices. These kinds of rhetorical analyses help us to understand the meaning of our choices and raise the possibilities of alternatives.

A rhetorical approach to writing well in science would not set forth a set of formal prescriptions to be followed for propriety's sake, nor would it suggest a set of universally advisable procedures. A rhetorical approach would attend to the range and meaning of current practices and then suggest how to deploy them appropriately and effectively within specific contexts. The current practices, properly understood, within themselves contain their own recommendations for appropriateness and advisability, for they embody a history of inventions and choices by prior writers addressing and shaping similar situations. The following practical morals of the analyses of this book neither identify a set of rules nor define a limited linguistic technology of responses for all of science. Science is no one single thing, and rules and language technology are continually changing in form and meaning. The advice I offer, rather, is to hold up for reconsideration the concerns embodied within the historical development and current practice of scientific writing. Reexamination of fundamental concerns gives us a position from which to reconsider our current choices.

- Consider Your Fundamental Assumptions, Goals, and Projects

The underlying epistemology, history, and theory of a field cannot be separated from its rhetoric. The rhetorical action is mounted within a conceived world and in pursuit of ultimate as well as immediate goals. The more you understand the fundamental assumptions and aims of the community, the better able you will be able to evaluate whether the rhetorical habits you and your colleagues bring to the task are appropriate and effective. Much of the rhetorical change we have observed in various periods has been driven by the gradual realization of the rhetorical consequences of epistemological commitments and communal goals. The realization of the empiricist project (as embedded in an agonistic social structure) lies behind much of the movement of the experimental article in the seventeenth and eighteenth centuries. Similarly behaviorism, as we have seen, has had a deep effect on the institutionalized rhetoric of experimental psychology. Greater rhetorical self-consciousness may not have changed the overall shapes of the rhetorical practices that eventually emerged, but it may have led to those results more rapidly and with greater precision. Indeed, some of the current problems of

writing in political science seem to come from inadequate consideration of the epistemic consequences of the rhetoric adopted.

And conversely, epistemological change and reformulations of goals have come in the wake of rhetorical change. The ideal of Newtonian science structured as a comprehensive deductive system of great generality can be seen as fostered by Newton's discoveries of the most advisable procedures for winning his arguments. Newton's abilities to recognize and heighten the epistemic consequences of his rhetorical struggles presented him with powerful tools to transform science.

More locally, it is useful to understand how your individual assumptions and goals fit in with the epistemology and goals of the community you are participating in and contributing to. If your work is simply harmonious with disciplinary assumptions and projects, and if the discipline has forged a rhetoric adequate to its beliefs and tasks, you can adopt the local rhetoric with a fuller understanding and commitment. If, however, you find yourself in some way at odds, you can begin to understand the rhetorical task before you—both in developing terms appropriate to your emerging claims and in finding ways to make your claims intelligible and persuasive to peers committed to other beliefs and rhetorics. Newton, as we have seen, had to struggle with the Baconian empiricism and the Cartesian skepticism he perceived around him in order to find ways first to present his findings and then to assert arguments of great certainty and generality.

- Consider the Structure of the Literature, the Structure of the Community, and Your Place in Both

At any particular moment the literature of a field is structured around issues and themes historically evolving and of current moment. The prior literature establishes a conversation that has established accepted understandings, visions of the world, topics of concern and open questions. As you step in to add your utterance, it necessarily must address the rhetorical situation established by that literature, for certainly it will be received and measured against that communal construction. Even a newly emerging field with a small and loosely structured literature draws on the literary capital of other specialties out of which it emerged; however, the protean possibilities of a newly emerging field offer opportunities for direction-setting innovations. In more established fields, more must be uprooted to significantly alter the rhetorical dynamics.

The explicit recognition of the importance of prior statements has been realized through the techniques of overt intertextuality developed over the last few centuries (such as references and citations, article in-

troductions, reviews of literature, eponymity, and shared theory). Thus in addition to evaluating the state of the discussion to evaluate the rhetorical moment, you must represent that state of the discussion so as to locate and justify your contribution. Swales's schematic analysis of the four moves of a typical article introduction (establishing the field, summarizing previous research, preparing for present research, and introducing present research) is precisely an elaboration of the standard current strategics of this generic task.

Explicit intertextuality also helps mobilize a range of literature to support and extend the new claim. The more firmly you can tie the claim to the accepted intertextual web, the more persuasive the claim appears. The more centrally the claim can be placed at a crucial juncture in the web, the greater significance it will have. Finally, explicit intertextuality offers opportunities for rewriting history from your vantage point. The opportunities for persuasive restructuring of the literature depend both on how tightly and convincingly the literature currently seems structured to members of the community and on the powerfulness of the new perspective from which you wish to re-view the prior conversation.

The need to assert your work against an explicitly recognized literature heightens the need to know how and why you are reading that literature. Reading the literature against a developing schematic view of what problems the discipline has addressed, what the discipline has learned, where it is going, who the major actors are, and how all these things contribute to your own project, helps you interpret the literature actively in support of your developing project. The highly developed and self-conscious reading behaviors of the physicists interviewed for chapter 8 indicate the importance these individuals had placed on becoming skilled, active readers of their discipline.

The rhetorical moment one speaks to is shaped not only by a history of paper, but by living persons whom you wish to move in some manner by your written comments. These individuals share, to differing extents, communal assumptions and projects as well as a familiarity with the disciplinary literature. However, these individuals are also driven by their own active projects and view the communal legacy through their own interests and schema.

To some extent, you can know parts of your audience as individuals, through face-to-face interaction and familiarity with their writing; however, except in the most contained and tightly structured fields, you can come to know only a few individuals well, a wider group superficially, and the greater number of colleagues not at all. Through coming to know how statuses, roles, and relations tend to be structured in a field you can, nevertheless, gain a fairly good idea of your audience, and

even more of yourself in relation to that audience. Familiarity with the social structure of a community surrounds you with statuses, roles, norms, rights, obligations, appropriate attitudes, and acceptable actions. You learn what you must do and how you must act to participate in the activity of the community, what the acceptable degrees and ranges of variation are, and what sanctions are likely for violation.

In most cases, accepting your place within the social structure grants you sufficient voice to assert your projects, particularly if the projects are conceived and carried out well within the standards of the community; occasionally, however, establishing new social relations can have revolutionary impact on the community. Compton's arguments were credible to his peers because he acted as a physicist in his time and place should; he did so precisely because he himself was a committed physicist according to the standards of the time. On the other hand, Newton, who adopted the guise of a Baconian in his "New Theory" article, got into more fundamental persuasive difficulties, because he wished to carry a different kind of argument than was currently allowed Baconians. He had to rewrite the social structure and social relations, with himself at the top of a compelling hierarchy, in order to persuade the community of his experience and beliefs. The consequences of the restructuring extended far beyond the acceptance of his claims about colors.

- Consider Your Immediate Rhetorical Situation and Rhetorical Task

Within all the fundamental frameworks of disciplinary and personal assumptions and goals, of structured literature and structured community, the rhetorical moment presents itself and you must define an immediate rhetorical task. Large issues coalesce into a specific question, large research goals take shape in a specific project, a local environment of immediately relevant claims and counterclaims emerges from the literature, and you find yourself positioned in a certain relationship with your colleagues. The more clearly you understand this emergent rhetorical situation, the more precisely and effectively you can choose what you do next. Assessing the situation helps you judge what kind of statement is called for, if any. The situation may seem to call for an immediate written response, it may call for further experiments to address unresolved questions and criticisms and to result in a compelling published answer, or it may call for fundamental investigations out of which whole new kinds of statements will grow.

Within the conversation of communal science, all choices have rhe-

torical import, for they help shape the next statement to be made. Compton's sequence of investigations and papers reveals consistent rhetorical choices as to how more satisfactory and persuasive claims might be developed and pressed. Newton's hand-to-hand combat over his optical claims reveals continual rhetorical choice making. No less do all the cases discussed here show the impact of rhetorical attempts to address the rhetorical moment, although the agonistic struggle may not be nearly as dramatic. With greater or lesser clarity, each writer has set out to make some argumentative gain within the field at a particular moment in the communal discussion.

• Consider Your Investigative and Symbolic Tools

The tools available to pursue goals of asserting claims within science are dialectically related empirical experience and symbols. The textual analyses here have revealed some of the resources available within scientific use of language and the kinds of impacts and actions realized by these resources. The genre of experimental article has found ways of bringing to bear on any particular argument the literature of the field, the currently accepted theory, deductive reasoning, representations of method, and representation of empirical experience. At particular moments, other forces are also brought to bear.

No less are the panoply of investigative tools rhetorically significant, for the scientific argument hangs on the quality and character of the evidence. Experimental and observational techniques are precisely ways of transforming nature into symbolic representations, which then have meaning for claims and arguments asserted on the symbolic plane. Choice of the investigative tool determines the kind of evidence available to generate new claims and to bolster old claims. A new method of investigation can bring a powerful resource to an argument by generating data of more exact relevance to the issues in question, by exposing new issues, and by creating a new kind of symbolic grounds on which to carry out the argument.

Thus a key issue in developing rhetorically effective science is considering how you may make nature your ally. On the most simple level, of course, this means advancing claims consonant with the available evidence (symbolic representations of empirical experience). More deeply, however, this means several other kinds of strategic choices. You can choose to pursue investigations that are likely to result in strong and striking evidence for the emergent claims. You can choose investigations where you suspect the emerging evidence is likely to expose new issues or reopen old ones. Or you can choose to employ new or different

investigative tools that you suspect will make the familiar look different, that will make the hidden visible in powerful ways. By shaping your research program you can use empirical experience as a heuristic to generate new statements about nature. Thus which research program to pursue and which means to use to pursue that program are important rhetorical choices affecting the kinds of claims and arguments that will emerge at the end. Shrewd guesses as to what kind of researches will produce empirical leverage against symbolic issues can generate much ultimate rhetorical power. Zuckerman's study of Nobel Prize winners reveals how much conscious thought these eminent scientists put into choosing what to investigate and how to investigate it so as to produce those powerful statements that win prizes *(Scientific Elite)*.

• CONSIDER THE PROCESSES OF KNOWLEDGE PRODUCTION

Although it is the final, publically stated claim that has rhetorical power, one cannot simply think only in terms of the final shape claims will take. Early choices of questions to consider, claims to pursue, literature to read, colleagues to discuss ideas with, investigative techniques to employ, analyses to carry out, and so on will all affect what kind of product will emerge at the end. These choices will generate thinking, data, formulations, and arguments which may well find expression in the final article. Moreover, the experimental article requires a certain amount of explicit representation of selected parts of the process that goes into its creation, such as the after-the-fact reconstruction of the intellectual genealogy in the review of the literature, the focused procedural account of methods, and the selective narrative of results. Finally, the representation of the final paper implies a web of activities and relations engaged in by the author as part of the construction of the argument, implicit activities that may be summed up by saying that the author has in the preparation of the article acted as a scientist (with whatever local meaning that takes on within the relevant specialty).

Because the final text is so dependent on the process by which it is produced, it is important to consider how you should go about producing the text so as to wind up with the kind of statement you hope for, without leaving yourself open to charges of fraud for representing a process that did not occur or improper conduct for not living up to implied behavior. In fact, process is so important to the production of persuasive scientific arguments that the final representation or writing-up seems a limited activity, with all the major parameters of the text determined by prior decisions. Well-considered procedure is not only good science, it results in good rhetoric.

Just as a consideration of the process of text production helps gain control of the final text, an anticipation of a text's reception helps gain control of the meaning likely to be attributed to a text. Given the positions held by colleagues, the kinds of arguments previously used, and the dynamics of competing research programs, you can often gain some sense of what kind of impact a reported experiment or a newly framed argument is likely to have. Anticipation of the impact can help you shape the presentation to forestall unwanted responses and heighten the desired ones. You can cut opposition off at the pass, press your advantages, draw in desired audiences, and provoke desired follow-up work.

• Accept the Dialectics of Emergent Knowledge

Despite the attempt to understand and control all the dynamics of written communication, we are always reaching into the unknown. The outcomes of investigations, writing processes, and social interaction can never be anticipated with clarity and certainty. Having made our best guesses as to how to proceed, we must then be ready to notice what develops and revise our plans accordingly.

As events unfold we discover that our nascent formulations match and mismatch in curious ways with the data we pursue in order to explore those investigations. The dialectical struggle to find ways of generating data significant for our formulations and to then reconcile that data with those formulations can lead to manifold discoveries of new kinds of data, new kinds of claims, new issues to investigate and new methods of investigation. We do not know what we will find, and what we will be led to say by what we find. Although we need issues, assumptions, methods, hypotheses to drive our discovery process, we must be ready to accept the worlds revealed to us in our attempt to come to terms with what we discover. Otherwise, we may throw away our most promising stories.

Similarly, as we start to draw all the elements of our investigation together in the single location of a text, we are forced to reexamine how the parts fit together. Again this is a moment that calls for an openness of imagination, as we create a coherent account of the literature, issues, theoretical positions, investigative goals, empirical events, and conclusions we draw. Creating a single text provides us with a retrospective vision that can tighten threads of connections, reveal new issues and anomalies, excite new insights, and define new projects. As well, the formal requirements of completing a text puts us on the spot, forcing us to fill in the blanks as best we are able, to dig deeply into our thought

and experience to fulfill the outlines of the argument demanded by the rhetorical situation and our rhetorical tools. If we do not have the means to live up to the rhetorical demands, we are forced back into both the library and the laboratory.

And finally, having sent our text out into the world, we need to be open to what experience and thought others bring to the published formulations. We need to understand what kind of social reality the text becomes, so as to pursue the conversation of knowledge to the best advantage. Sometimes this may mean buttressing arguments, closing loopholes, and clearing up misunderstandings. These acts in themselves may lead to new discoveries or more powerful formulations. But often responses can teach us new contexts which generate new meaning for the work. Interaction with new realms of ideas, problems, and data can transform the claims. And the evolution of continuing work will assign a social meaning and pragmatic role for our formulations; our understanding of and reactions to that social meaning will influence our future investigations and formulations. To keep the conversation going, we must constantly reread the dynamics and meaning of the conversation and our place in it. An inability to recognize the continuing evolution of the communal projects will leave us singing the same old song, a song that may lose its meaning when sung out of season.

As we create the formulations that gain communal meaning as knowledge, we are bringing worlds into being. By identifying, selecting, recording, and making claims about empirical experience, we are bringing our experience of the world of objects into the human-created world of symbolic actions. Although our procedures of generating and using statements through our empirical experience bring the world of objects in relation to the world of symbols, the world of symbols does not exist and our knowledge does not exist until we make them within the social world, as protean and transient as that is. We cannot fully know what we bring into being until it has taken its place in our world, but then, since the world immediately starts changing around it, what we have made changes. To gain what limited mastery we can over this changing social world of symbols, we should follow Odysseus, who must catch Proteus in his own lair on the edge of the ever-changing sea.

In short, writing well in science means to apply to one's own situation and tasks the same rhetorical understanding applied in this book to a wide range of texts and writers. Playing chess well involves an analytical knowledge of the most interesting and informative of prior games, and then applying that knowledge to the position in front of you. By recognizing the power of different moves in different contexts, you can then mobilize that power. To see the practices and institutions of scientific

writing as protean and evolving is not to discredit them as transitory, but to grant them the proper respect for the great power they realize.

The Limits of Rhetorical Self-Awareness and the Teaching of Writing

To hold every statement up for rhetorical examination is, of course, an unrealistic demand. Both art and science are long, and life is short. We must make choices as to where we devote our energies. It seems enough to ask a physicist to learn physics and the symbol system of mathematics. Should we then also demand competence in the other symbol system of words? And how much competence? Certainly not a Ph.D. in rhetoric. On the other hand, more than a junior high school course in grammar and spelling seems required.

Just as scientists in different specialties and of different personal bents master mathematics in different areas and to different depths, depending on applied need and theoretical grasp, so too will rhetorical needs and command vary. In fields with restricted, slowly evolving, and apparently adequate rhetorical practices, a thorough practical command within the regularized domain may need to be supplemented only by an analysis of the implications and a cursory knowledge of basic rhetorical concepts. Then, if the rhetorical problems heat up, the individual scientist can at least recognize the problem and know where to begin looking for answers. Interdisciplinary fields that draw on several bodies of knowledge may require greater virtuosity and understanding of the technologies of literature discussion, synthesis, and citation; as well, the ability to analyze the communicative dynamics of different fields may aid both interpretation of the varied literatures and the formulation of arguments for different venues. Fields with rapidly evolving theory require other skills, such as complex argumentative structuring and organizational flexibility. Fields that depend on descriptive taxonomies or historical reconstructions may call for large depictional and narrative repertoires, while other fields need tricks of aggregation. Choices are necessary as to which parts of rhetoric are likely to have the biggest payoffs in each case.

However, here is where the big difference currently exists between rhetoric and mathematics. Needs for mathematics are well recognized and often well-defined. Scientists are likely to know when they have need of additional mathematical tools, what those tools are, and where to go to find out about them. They know which books they must study, which courses to regret having by-passed, which colleagues in the

mathematics department to talk to. Moreover, their colleagues in the math department are used to applying their abstract knowledge to problems in the natural and quantitative social sciences, so that a broad and useful common ground for discussion exists. Even when the mathematics is new or exotic or when the application is unusual, so that the right tool does not immediately come to hand, at least the scientist and mathematician know they can and should be talking with each other.

Scientists, however, are unlikely to recognize difficulties in framing successful investigations and claims as rhetorical, unlikely even to be aware of rhetoric as a relevant field. Even if they are aware that their claim making can be fruitfully conceived in rhetorical terms, they may have little idea of what the relevant branches of rhetoric are, what books to read, or whom to talk to. Finally, even if they find a willing rhetorician to talk to, very few of those rhetoricians have had any experience in talking to scientists and applying rhetorical knowledge to problems of scientific communication.

Rhetoric has only recently begun to take up the challenge of scientific use of language. While classical rhetoric does have a well-defined body of knowledge of several discrete parts and well-known procedures of application, appropriate to different kinds of situations, that rhetorical technology applies only to politics, the courts, and similar contexts. No such technology exists for knowledge-generating disciplines, or more particularly the sciences. Few rhetoricians have attempted serious studies of scientific use of language. While a few interesting propositions have been put forward, substantiated claims based on examination of actual language practices in science have been rare.

We need thoroughgoing and wide-ranging research into the historical and current rhetoric within the sciences and other knowledge-generating communities to gain a grasp of the range of practices, the thematic interactional concerns, the local emergence of typified forms and actions, and the implications for socially produced knowledge. We need far more than one writer's idiosyncratic glimpses into only a few scattered rhetorical locations, such as offered here. Only with a communally shared, reliable set of formulations will we be able to develop intelligent curricula to meet the local rhetorical needs of students entering into specific knowledge-generating communities, to frame efficient analytical procedures to allow writers to analyze their rhetorical situations and rhetorical options, and to present to other disciplines a knowledge and technology that will be of obvious use and power. Only then may other disciplines recognize the deeply rhetorical character of their enterprises, realize that the discipline of rhetoric can offer them important tools for their symbol-creating tasks, and wish to talk with us. Then the fun will begin.