CHAPTER 1

Rhetorical Analysis

We readily concede that the law courts and the political forum are special cases of our everyday world, a world in which social reality is uncontroversially the product of persuasion. Many of us can also entertain a possibility Aristotle could never countenance: the possibility that the claims of science are solely the products of persuasion. We live in an intellectual climate in which the reality of quarks or gravitational lenses is arguably a matter of persuasion; such a climate is a natural environment for the revival of a rhetoric that has as its field of analysis the claims to knowledge that science makes.

Rhetorically, the creation of knowledge is a task beginning with self-persuasion and ending with the persuasion of others. This attitude toward knowledge stems from the first Sophistic, an early philosophical relativism made notorious by Socrates. In spirit, the *Rhetoric*, my master theoretical text, is also Sophistic, its goal "to find out in each case the existing means of persuasion." It is a spirit, however, that Aristotle holds firmly in check by limiting the scope of rhetoric to those forums in which knowledge is unquestionably a matter of persuasion: the political and the judicial. If scientific texts are to be analyzed rhetorically, this Aristotelian limitation must be removed; the spirit of the first Sophistic must roam free.

Whether, after rhetorical analysis is completed, there will be left in scientific texts any constraints not the result of prior persuasion, any "natural" constraints, remains for the moment an open question. In the meantime, as rhetorical analysis proceeds unabated, science may be progressively revealed not as the privileged route to certain knowledge but as another intellectual enterprise, an activity that takes its place beside, but not above, philosophy, literary criticism, history, and rhetoric itself.

The rhetorical view of science does not deny "the brute facts of nature"; it merely affirms that these "facts," whatever they are, are not science itself, knowledge itself. Scientific knowledge consists of the current answers to three questions, answers that are the product of professional conversation: What range of "brute facts" is worth investigating? How is this range to be investigated? What do the results of these investigations mean? Whatever they are, the "brute facts" themselves mean nothing; only statements have meaning, and of the truth of statements we must be persuaded. These processes, by which problems are chosen and results interpreted, are essentially rhetorical: only through persuasion are importance and meaning established. As rhetoricians, we study the world as meant by science.

Thirty years ago the humanistic disciplines were more easily definable: historians of science shaped primary sources into chronological patterns of events; philosophers of science analyzed scientific theories as systems of propositions; sociologists of science scrutinized statements aimed at group influence (Markus 1987, p. 43). In the last two decades, however, the humanities have been subject to what Clifford Geertz has called "a blurring of genres." As a result, "the lines grouping scholars together into intellectual communities . . . are these days running at some highly eccentric angles" (1983, pp. 23–24).

David Kohn, Sandra Herbert, and Gillian Beer on Darwin: are they writing intellectual history or literary criticism? Ian Hacking on gravitational lensing: is he doing philosophy or sociology? Arthur Fine on Einstein: is he producing philosophy or intellectual history? Are Steve Woolgar and Karin Knorr-Cetina studying the scientific paper from the point of view of sociology or rhetorical criticism? Is Evelyn Keller's work on Bacon epistemology, psychology, or literary criticism? When Michael Lynch analyzes laboratory shop talk, is he doing ethnomethodology or rhetoric of science?

These intellectual enterprises share a single methodological presupposition; all, to paraphrase Barthes, "star" their texts; all assume with Geertz that "the road to discovering . . . lies less through postulating forces and measuring them than through noting expressions and inspecting them" (1983, p. 34). To address Einstein's philosophy, Fine becomes a historian. Latour and Woolgar discover the intellectual structure of science not through philosophical analysis but through the ethnomethodology of the laboratory. Keller approaches

Bacon's epistemology not by reconstructing his arguments but by analyzing his metaphors; Beer treats the *Origin* less like an argument than like a novel by George Eliot or Thomas Hardy.

Rhetorical analysis describes what all of these scholars of science are doing; it defines the intellectual enterprise of workers as different in outlook and training as Gillian Beer and Steve Woolgar.[1] For such scholars, the speculative knowledge of the sciences is a form of practical knowledge, a vehicle of practical reasoning, whose mark "is that the thing wanted is *at a distance* from the immediate action, and the immediate action is calculated as the way of getting or doing or securing the thing wanted" (Anscombe 1957, p. 79). The *Origin of Species* is speculative knowledge, certainly; from a rhetorical point of view, however, it is also practical knowledge, the vehicle by means of which Darwin attempted to persuade his fellow biologists to reconstitute their field, to alter their actions or their dispositions to act.

To call these intellectual activities rhetoric of science, then, is only to register a claim already staked and mined; to view these apparently distinct enterprises as rhetoric is merely to make available to all a coherent tradition, a set of well-used intellectual tools.

Rhetoric of science differs from literature and science, a branch of study that also "stars" its texts. The texts privileged by literature and science are traditionally literary; the science of an era is studied for its ability to illuminate the literary productions of that era: Katherine Hayles's *The Cosmic Web* trains the concepts of scientific field theory on a set of contemporary novels influenced by this theory. In contrast, rhetoric of science proposes by means of rhetorical analysis to increase our understanding of science, both in itself and as a component of an intellectual and social climate. From this perspective, when Gillian Beer studies the impact of Darwin on Victorian intellectual life, she is doing not literature and science but rhetoric of science.

To say that a rhetoric of science views its texts as rhetorical objects, designed to persuade, is not to deny that there is an aesthetic dimension to science. From a rhetorical point of view, however, this dimension can never be an end in itself; it is always a means of persuasion, a way of convincing scientists that some particular science is correct. In science, beauty is not enough: Descartes's physics is beautiful still, but it is not still physics.

Rhetoric Applied to Scientific Texts

In a neo-Aristotelian rhetoric of science, the apparatus of classical rhetoric must be generally applicable; a formulation must be developed that is recognizably classical and, at the same time, a theory of the constitution of scientific texts. This is not to say that classical ideas of style, arrangement, and invention must be mapped point for point onto these texts. The notion is not that science is oratory; but that, like oratory, science is a rhetorical enterprise, centered on persuasion. Instead of searching for exact correspondences, we must, as we proceed, achieve a general sense that the categories of classical rhetoric can explain the observable features of scientific texts.

This task is made easier by the existence of a long tradition of rhetoric and rhetorical analysis. Classical rhetoric was never a unitary system, nor was the rhetorical tradition unified throughout its history: Aristotle, Cicero, Quintilian differ, as do Campbell, Whately, and Blair. Doubtless, if more texts survived, even more disagreement among classical authors would be evident.

But it is the continuities in the rhetorical tradition that are most striking, continuities that subsist generally throughout medieval and modern rhetoric. Writers still find arguments where classical orators found them; the organization of writing still owes a debt to classical ideas of arrrangement; and rhetoricians still think of style in terms that are largely classical. When young people learn to write, they still learn what Quintilian taught.

The rhetorical analysis of science is made plausible by the close connection between science and rhetoric in the ancient world. Early Greek thought concerning the material world fluctuated wildly. To Thales the fundamental substance was water; to Anaximenes it was air. To Heraclitus all was flux; to Parmenides change was an illusion. To this *embarras de richesses* there were two reactions. The first was to ensure the certainty of knowledge; this was the way of Plato and Aristotle. The second was to regard knowledge as human and changeable, as rhetoric; this was the way of the Sophists.

The problem that rhetoric of science addresses, then, was set early in the intellectual history of the West. And then as now, this problem cannot be addressed unless rhetorical analysis includes not only the style and arrangement of science, but also those of its features usually regarded as unrhetorical—features commonly construed not as rhetoric but as the discovery of scientific facts and theories. From the rhetorical point of view, scientific discovery is properly described as invention.

Why redescribe discovery as invention? To discover is to find out what is already there. But discovery is not a description of what scientists do; it is a hidden metaphor that begs the question of the certainty of scientific knowledge. Discovered knowledge is certain because, like America, it was always there. To call scientific theories inventions, therefore, is to challenge the intellectual privilege and authority of science. Discovery is an honorific, not a descriptive term; and it is used in a manner at odds with the history of science—a history, for the most part, of mistaken theories—and at odds with its current practice, a record, by and large, of error and misdirection. The term *invention,* on the other hand, captures the historically contingent and radically uncertain character of all scientific claims, even the most successful. If scientific theories are discoveries, their unfailing obsolescence is difficult to explain; if these theories are rhetorical inventions, no explanation of their radical vulnerability is necessary.[2]

Stasis

At any time, in any science, scientists must make up their minds about what needs to be explained, what constitutes an explanation, and how such an explanation constrains what counts as evidence. When scientists think about matters of explanation, they are deciding what it is to do science. In rhetorical terms, they are using *stasis* theory, which is an established part of invention: a set of questions by means of which we can orient ourselves in situations that call for a persuasive response. In courtroom arguments, we consider whether an act was committed (*an sit*); whether it was a crime (*quid sit*); whether the crime is justified in some way (*quale sit*). In the analysis of law, these *stases* have a central role; in the analysis of science, their centrality is equally apparent.

1. *An Sit.* In the sciences, what entities really exist? Does phlogiston? Do quarks? Before Einstein's papers on Brownian movement, the existence of atoms was in question; afterward, their existence was regarded as confirmed.

2. *Quid Sit.* Given that certain entities exist, what is their exact

character? From antiquity, light has been steadily the subject of scientific scrutiny. Is light Aristotle's alteration in a medium, Descartes's pressure, Newton's particle, Young's wave (another alteration in a medium), or the zero-mass particle of quantum electrodynamics?

3. *Quale Sit.* Even if the character of an entity or phenomenon remains roughly the same, the laws governing it may be radically different: the same law of refraction that is, for Newton, the result of deterministic forces acting on minute particles is, for Feynman, the product of probabilistic ones acting on zero-mass particles.

Particular scientific texts emphasize particular *stases.* Although Einstein incidentally established the physical existence of atoms, he was mainly concerned with the *quale sit* of Brownian motion. Papers in evolutionary taxonomy establishing a new species mainly support the *quid sit* of existence, but they are also concerned with the *quale sit* of evolutionary theory. In every case the *stases* focus the scientist's attention on a particular aspect of the problem before him: Newton and Descartes, for instance, were both concerned with the nature of white light, the *quid sit.*

There is a final *stasis* applicable to both rhetoric and science: whether a particular court has jurisdiction. Whether something is a scientific theory depends on who is doing the judging. Newton's formulation of the theory of light remained the same throughout his career. At first it was rejected; its later acceptance did not depend on any alteration of the theory but on a change of jurisdiction. In the first court of opinion, Newton was judged by rules of others' making; in the final court, the rules were Newton's own.

Jurisdiction is also important in adjudicating the relationships between science and society. At what point do decisions cease to be internal to a science? The Inquisition saw itself as an appropriate arbiter of all knowledge, including Galileo's scientific theories. In modern times this determination is usually, and rightly, made by the scientific community. But even contemporary American courts see themselves as proper judges of the social impact of recombinant DNA research.

At any one time, in any one science, there are proper and improper ways to respond to the first three *stases.* For Aristotle, for example, the phenomena in need of explanation are those that naturally present themselves; what accounts for the motion of a stone released from the thrower's hand? This is a case of violent motion, a movement whose efficient cause is the application of a force to an object,

overcoming its material cause, its *gravitas.* There is no violent motion without direct contact: a stone thrown in the air continues its motion after it leaves the thrower's hand only because of the impulsive power of the air directly behind it. The stone's initial trajectory is the formal cause of this violent motion. At the height of that trajectory, natural motion takes over; the stone begins to fall, seeking its natural place, the final cause of its motion. The material cause is again the stone's *gravitas,* its formal cause the downward trajectory itself, its efficient cause the distance from its natural place. For Aristotle scientific explanation is essentially qualitative, according to the four causes; mathematics has no place in physics.

In his *Principia,* Newton escapes the Aristotelian *an sit;* he no longer takes as *explanandum* the traditional topic of motion. For Newton it is not motion but change of motion that requires explanation. Motion itself—intuitively, the natural puzzle—is an *explanandum* no longer in the realm of science. Moreover, Newtonian explanations that do not enumerate all four causes can still be scientific. The material cause of change of motion is largely bracketed, and its final cause assigned to theology. The efficient and formal causes are privileged, and the formal cause is given a mathematical interpretation: change of motion is explained according to strict mathematical relationships among such nonobservables as force and mass. Such relationships permit quantitative solutions to problems in physics. Wherever possible, these problems have an experimental realization: in principle, though not in fact, Newton will assert only what he can observe under experimental constraints or can infer directly from controlled observation.

Because the presuppositions of Aristotle and Newton were opposed, because their notions of evidence and explanation seriously diverged, the sciences they created differed radically. Differently interpreted, the *stases* can lead—in fact, have led—to radically different conceptions of science. Since they precede science, the province of these interpretations cannot be science; their proper province is rhetoric.

Logos

The common topics are a staple of classical rhetorical invention; comparison, cause, definition—these and their fellows are the traditional places where rhetoricians can find arguments on any given topic. These same common topics are also an important source for arguments in science—in Newton, for example. In his *Opticks*, Newton defines a light ray twice. Early in this work he provides a definition in terms of the observable: light behaves *as if* it were made up of tiny particles. Later Newton defines light in terms of a hypothesis concerning the constitution of matter: light *may actually consist* of tiny particles. The difference in these definitions reflects a change in persuasive purpose. By means of the first definition, Newton hopes to persuade the skeptical scientist of the truth of his analysis of light; to agree, this scientist need not subscribe to Newton's speculative atomism. By means of the second, Newton hopes that this same scientist will seriously entertain atomism as a scientific hypothesis.

In Newton's optical works, the common topics are used heuristically as well as persuasively. Newton undermines Descartes's analysis of color by means of the topic of comparison: he contrasts Descartes's theory with his own incontrovertible experimental results. Concerned about the material constitution of light, he addresses the topic of cause: the sensation of light, he speculates, is evoked when its tiny particles impinge on the retina. In his presumption of the rectilinear propagation of light, he relies on the topic of authority; everybody since Aristotle has taken this as true.

In each case, we might say that Newton defines scientifically, compares scientifically. But in none of these instances is it possible to define a scientific sense for the common topics that is qualitatively distinct from their rhetorical sense: these sources for arguments in science and rhetoric do not differ in kind.

In addition to the common topics suitable to all argument, there are special topics that provide sources of argument for each of the three genres of speeches: forensic, deliberative, and epideictic. Forensic texts establish past fact; they are so named because their paradigm is the legal brief; their special topics are justice and injustice. Epideictic texts celebrate or calumniate events or persons of importance; their paradigms are the funeral oration and the philippic; their special topics are virtue and vice. Deliberative texts establish future policy; their paradigm is the political speech; their special topics are the advantageous and the disadvantageous, the worthy and the unworthy.

Scientific texts participate in each of these genres. A scientific report is forensic because it reconstructs past science in a way most likely to support its claims; it is deliberative because it intends to

direct future research; it is epideictic because it is a celebration of appropriate methods. Analogously, scientific textbooks strive to incorporate all useful past science, to determine directions for future research, and to commend accepted methods. But science also has special topics of its own, unique sources for its arguments. Precise observation and prediction are the special topics of the experimental sciences; mathematicization is the special topic of the theoretical sciences. But there is considerable reciprocity. In the experimental sciences, mathematization is also a topic, and it provides arguments of the highest status; and in the theoretical sciences, at least by implication, arguments from mathematics are anchored in the special topics of prediction and observation.

But are observation, prediction, and mathematization *topics?* Science is an activity largely devoted to the fit between theories and their brute facts; the better the fit, the better the science. Surely, observation, prediction, and mathematization are not topics, but means to that end. In prediction, the confrontation between theory and brute fact is at its most dramatic. Einstein's theory of general relativity forecast the never-before observed bending of light in a gravitational field; Crick's theory of the genetic code predicted that an otherwise plausible variant—the codon UUU—would never occur. Both predictions insisted on the participation of nature; nature, not human beings, would clinch the argument. Einstein's theory was confirmed by the bending of stellar light as measured during a total eclipse; Crick's was disconfirmed by the discovery of a UUU codon. In both cases, it seems, we have left rhetoric behind. We seem to be in direct contact with the brute facts as the criterion for theoretical truth: stellar photographs in the first case, instrument readings in the second.

But this line of argument fails: in neither case did the brute facts point unequivocally in a particular theoretical direction. In fact, in no scientific case do uninterpreted brute facts—stellar positions, test-tube residues—confirm or disconfirm theories. The brute facts of science are stellar positions or test-tube residues *under a certain description;* and it is these descriptions that constitute meaning in the sciences. That there are brute facts unequivocally supportive of a particular theory, that at some point decisive contact is made between a theory and the naked reality whose working it accurately depicts, is a rhetorical, not a scientific, conviction. Observation, prediction, measurement, and their mathematization: these are sources for the arguments in science in the same way—exactly the same way—that the virtuous is the source of arguments for the epideictic orator.

The Structure of Argument. For Aristotle, scientific deduction differs in kind from its rhetorical counterpart. True, both are conducted according to the "laws" of thought. But rhetorical deduction is inferior for two reasons: it starts with uncertain premises, and it is enthymematic: it must rely on an audience to supply missing premises and conclusions. Since conclusions cannot be more certain than their premises, and since any argument is deficient in rigor that relies on audience participation for its completion, rhetorical deductions can yield, at best, only plausible conclusions. Rhetorical induction, reasoning from examples, is equally marked by Aristotle as inferior to its scientific counterpart because of its acknowledged inability to guarantee the certainty of its generalizations: examples illustrate rather than prove.

Aristotle notwithstanding, rhetorical and scientific reasoning differ not in kind but only in degree. No inductions can be justified with rigor: all commit the fallacy of affirming the consequent; as a result, all experimental generalizations illustrate reasoning by example. Deductive certainty is equally a chimera; it would require the uniform application of laws of thought, true in all possible worlds; the availability of certain premises; and the complete enumeration of deductive chains. But of no rule of logic—not even the "law" of contradiction—can we say that it applies in all possible worlds. Moreover, even were such universal rules available, they would operate not on certain premises but on stipulations and inductive generalizations. In addition, all deductive systems are enthymematic: the incompleteness of rhetorical deduction is different only in degree, not in kind, from the incompleteness of scientific deduction. No deductive logic is a closed system, all of whose premises can be stipulated; every deductive chain consists of a finite number of steps between each of which an infinite number may be intercalated (Davis and Hersh 1986, pp. 57–73). Because the logics of science and rhetoric differ only in degree, both are appropriate objects for rhetorical analysis.

Ethos and *Pathos*

Scientists are not persuaded by *logos* alone; science is no exception to the rule that the persuasive effect of authority, of *ethos*, weighs heavily.

The antiauthoritarian stance, the Galilean myth canonizing deviance, ought not to blind us to the pervasiveness of *ethos*, the burden of authority, as a source of scientific conviction.[3] Indeed, the progress of science may be viewed as a dialectical contest between the authority sedimented in the training of scientists, an authority reinforced by social sanctions, and the innovative initiatives without which no scientist will be rewarded.

Innovation is the *raison d'être* of the scientific paper; yet in no other place is the structure of scientific authority more clearly revealed. By invoking the authority of past results, the initial sections of scientific papers argue for the importance and relevance of the current investigation; by citing the authority of past procedure, these sections establish the scientist's credibility as an investigator. All scientific papers, moreover, are embedded in a network of authority relationships: publication in a respected journal; behind that publication, a series of grants given to scientists connected with a well-respected research institution; within the text, a trail of citations highlighting the paper as the latest result of a vital and ongoing research program. Without this authoritative scaffolding, the innovative core of these papers—their sections on results, and their discussions—would be devoid of significance.

At times, the effects of scientific authority can be stultifying: collective intellectual inertia blocked the reception of heliocentric astronomy for more than a century; Newton's posthumous authority retarded the reemergence of the wave theory of light. At other times, perhaps more frequently, authority and innovation interact beneficially; consider heliocentric astronomy between Copernicus and Kepler, the theory of light between Descartes and Newton, the concept of evolution in Darwin's early thought: in each of these cases we can see the positive results of the dialectical contest between authority and innovation. These examples alert us to the fact that there is no necessary conflict between originality and deference. One of the persuasive messages of authority in science is the need to exceed authority; indeed, the most precious inheritance of science is the means by which its authority may be fruitfully exceeded: "Was du ererbt von deinen Vätern hast / Erwirb es, um es zu besitzen" ("You must earn what you inherit from your fathers; you must make it your own"; Goethe, quoted in Freud 1949, p. 123).

At the root of authority within science is the relationship of master to disciple. To become a scientist is to work under men and women who are already scientists; to become a scientific authority is to submit for an extended period to existing authorities. These authorities embody in their work and thought whatever of past thought and practice is deemed worthwhile; at the same time, they are exemplars of current thought and practice. In their lectures, they say what should be said; in their laboratories, they do what should be done; in their papers, they write what should be written.

As long as science is taught as a craft, through extended apprenticeship, its routes to knowledge will be influenced by the relationships between masters and disciples. The modern history of heliocentricity is one of progress from epicycles to ellipses. But this theoretical development was realized only through a chain of masters and disciples, surrogate fathers and adopted sons: Copernicus and Rheticus, Maestlin and Kepler. By this means, research traditions are founded, and the methodological and epistemological norms that determine the legitimacy of arguments are passed on as tacit knowledge.

An examination of the forms of authority within science reminds us that epistemological and methodological issues cannot be separated from the social context in which they arise: the early members of the Royal Society decided what science was, how it would be accomplished, how validated, how rewarded. But we need also to be reminded of another set of authority relationships: those between science and society at large. It was the paradoxical promise of early science that it would benefit society best when wholly insulated from larger social concerns. This ideological tenet becomes difficult to justify, however, in an age of nuclear power and gene recombination. Justification is especially difficult when science converts its exceptional prestige into a political tool to protect its special interests, perhaps at the expense of the general interest. The recombinant DNA controversy is a case in point.

Emotional appeals are clearly present in the social interactions of which science is the product. In fact, an examination of these interactions reveals the prominent use of such appeals: the emotions are plainly involved, for instance, in peer review procedures and in priority disputes. Anger and indignation are harnessed in the interest of a particular claim; they are part of the machinery of persuasion. When science is under attack, in cases of proposed research in con-

troversial areas, emotional appeals become central. The instance of proposed research in gene recombination is a good example of the fundamental involvement of science in issues of public policy, and of the deep commitment of scientists to a particular social ideology.

In addition, the general freedom of scientific prose from emotional appeal must be understood not as neutrality but as a deliberate abstinence: the assertion of a value. The objectivity of scientific prose is a carefully crafted rhetorical invention, a nonrational appeal to the authority of reason; scientific reports are the product of verbal choices designed to capitalize on the attractiveness of an enterprise that embodies a convenient myth, a myth in which, apparently, reason has subjugated the passions. But the disciplined denial of emotion in science is only a tribute to our passionate investment in its methods and goals.

In any case, the denial of emotional appeal is imperfectly reflected in the scientific texts themselves. The emotions, so prominent in peer review documents and in priority disputes, are no less insistently present in scientific papers, though far less prominent. In their first paper Watson and Crick say of their DNA model that it "has novel features which are of considerable biological interest" (1953b, p. 737). In his paper on the convertibility of mass and energy, Einstein says: "It is not impossible that with bodies whose energy-content is variable to a high degree (e.g. with radium salts) the theory may be successfully put to the test" (1952, pp. 67–71). In these sentences, key words and phrases—"novel," "interest," "successfully," "put to the test"—retain their ordinary connotations. Moreover, in Watson and Crick, "considerable" is clearly an understatement: the topic is the discovery of the structure of the molecule that controls the genetic fate of all living organisms.

Our science is a uniquely European product barely three centuries old, a product whose rise depended on a refocusing of our general interests and values. Its wellspring was the widening conviction that the eventualities of the natural order depended primarily not on supernatural or human intervention but on the operation of fixed laws whose preferred avenue of discovery and verification was quantified sensory experience. The ontological results of this epistemological preference defined the essence of nature and founded a central Western task: to control nature through an understanding of its laws. To this task, the specific values of science—such as the Mertonian norms of universalism and organized skepticism—are instrumentally subordinate. Equally subordinate are the values on which theory choice depends: simplicity, elegance, power. In such a view, *ethos, pathos,* and *logos* are naturally present in scientific texts: as a fully human enterprise, science can constrain, but hardly eliminate, the full range of persuasive choices on the part of its participants.

Arrangement

In science, the arrangement of arguments is given short shrift. It is hardly noticed, never taught; yet arrangement has always been important in modern science. Realizing its powerful effect, Newton cast his physics and recast his optics in Euclidian form. Indeed, during the three centuries of modern science, arrangement has become more, rather than less, important; more, rather than less, rigid. Currently, form is so vital a component that no paper can be published that does not adhere closely to formal rules. In fact, the arrangement of scientific papers has become so inflexible that even experienced scientists occasionally chafe under its restrictive principles: results in this section, discussion in that. But when P. D. Medawar, a scientist of wide influence, put his Nobel weight behind a mild reform—putting the discussion section first—his arguments were ignored rather than answered (1964, pp. 42–43).

Yet nothing is more artificial than the form of scientific papers. Experimental papers, for example, are not so much reports as enactments of the ideological norm of experimental science: the unproblematic progress from laboratory results to natural processes. It is of no consequence that such progress is far from unproblematic, or that the philosophical bases of this version of the scientific method have long been undermined. In experimental reports, arrangement is regarded as a sacred given.

There is another aspect of arrangement, one even more central to the operation of science. Aristotle's decision to privilege the proofs of logic and mathematics, to except them from the province of rhetoric, was itself rhetorical; it was a decision in favor of certain arrangements, a choice that rested on their presumed correspondence to the laws of thought. It is a truism that logical and mathematical proofs are purely matters of syntax, of form, austere tributes to the power of pattern to evoke the impression of inevitability:

All A is B
All C is A
All C is B

Like all syllogisms, this paradigm syllogism of science is sound only by virtue of its form, its arrangement. But so paradigmatic of absolute conviction have the forms of logic become, so binding has logical necessity seemed, that its force has been attributed to arguments in the natural sciences and, even, in the humanities: we speak of physical necessity and moral necessity, as if they and logical necessity were precisely analogous (Perelman and Obrechts-Tyteca 1971, pp. 193–260).

Style

From the beginning, stylistic choices in modern science have been deliberately trivialized: in the words of Bishop Sprat, the first historian of modern science, its communications must "return back to the primitive purity and shortness, when men delivered so many things in an equal number of words" (Sprat 1667, II, pp. xx). In such a program, the schemes and tropes of classical rhetoric are rigorously to be avoided. Nouns stand for natural kinds; predicates for natural processes. Syntax, the structure of the sentence, is only the reflection of reality, the structure of nature.

Scientific style remains oxymoronic at its core: modest in its verbal resources, heroic in its aim—nothing less than the description of reality. Accordingly, tropes like irony and hyperbole are barred; they draw attention away from the working of nature. Stylistic devices like metaphor and analogy likewise cannot be condoned; they undercut a semantics of identity between words and things. Should scientific prose favor the active or the passive voice? This quarrel over schemes—over the appropriate surface subject of scientific sentences—masks essential agreement among the antagonists. Regardless of surface features, at its deepest semantic and syntactic levels scientific prose requires an agent passive before the only real agent, nature itself. By means of its patterned and principled verbal choices, science begs the ontological question: through style its prose creates our sense that science is describing a reality independent of its linguistic formulations.

Despite these strictures, tropes like irony and hyperbole do appear regularly in scientific reports, belying the alleged reportorial nature of these texts and underscoring their true, persuasive purpose. Although the official view is that metaphor and analogy have only a heuristic function, that they wither to insignificance as theories progress, tropes are central to the scientific enterprise, and never disappear altogether. In the *Origin of Species*, for example, a central argument is the analogy between artificial breeding and natural selection. This analogy was not abandoned as the theory matured; instead, it was the means by which the theory has been maintained and extended. Analogy is also central to the whole enterprise of experimental science: laboratory experiments are scientifically credible only if there is a positive analogy between laboratory events and processes in nature.

In sum, in science arrangement has an epistemological task, style an ontological one.

Aristotelian Rhetoric Updated

To practice the rhetoric of science, then, is to make the *Rhetoric* the master guide to the exegesis of scientific texts. To perform this task effectively, the *Rhetoric* must be updated. The achievements of those squarely in the rhetorical tradition are the easiest candidates for incorporation into a neo-Aristotelian rhetoric of science. Of these, Chaim Perelman's work is most nearly central. His masterpiece, *The New Rhetoric*, written in collaboration with L. Olbrechts-Tyteca, has as its strategic aim the rehabilitation of rhetoric as a discipline whose task is the analysis of persuasion in the humanities and the human sciences. Although Perelman does not deal with the natural sciences, the analysis of these is a plausible extension of the scope of his theory.

One central New Rhetorical concept useful in the analysis of science is the "universal audience," an ideal aggregate that can refuse a rhetor's conclusions only on pain of irrationality. Although the universal audience has been attacked as an ontological category, there is no disagreement that its assumption is a valid rhetorical technique (Johnstone 1978, pp. 101–106). Indeed, it is a technique essential to the sciences. The real audiences for papers in taxonomy and theoretical physics are vastly different in their professional presuppositions; nevertheless, all scientists attribute to imagined colleagues standards of judgment presumed to be universal: not in the sense that everyone judges by means of them, but in the sense that anyone, having undergone scientific training, must presuppose them as a matter of course.

There is a more sweeping, and more telling, criticism of *The New Rhetoric*, the accusation that Perelman and Olbrechts-Tyteca are seriously derelict in their philosophical duty: "One is never sure whether the authors are thinking of rhetoric primarily as a technique or primarily as a mode of truth. One wonders, too, what status the authors are claiming for the book itself" (Johnstone 1978, p. 99). This criticism is a reminder to all of us to take an unequivocal stand on the epistemological status of our own inquiries. In my work, I view the techniques of rhetoric expounded by Perelman and Olbrechts-Tyteca, techniques such as analogy, as the means by which we are persuaded that any mode of inquiry, including that of science, is a mode of truth.

A neo-Aristotelian theory of rhetoric should also be prepared to incorporate the results of relevant modern thinkers, those who purport to reveal through their work enduring qualitative patterns that undergird apparently unique verbal behavior. In rhetoric, Aristotle finds three persuasive appeals, three levels of rhetorical analysis. In an analogous fashion, the Russian formalist Vladimir Propp finds that the dramatis personae of fairy tales exhibit thirty-one functions exercised in seven spheres of action; Freud divides the mind's functions into ego, superego, and id; Jürgen Habermas analyzes speech acts by means of their relationship to their validity claims, to their communicative functions, and to reality.

The incorporation of views as divergent as those of Propp, Freud, and Habermas into a neo-Aristotelian rhetoric of science necessitates the abandonment of strong ontological claims. Aristotle's psychology and that of Freud cannot be incorporated into a single coherent theory. In addition, an explanatory pattern in which we put great store may be, from another, equally legitimate, point of view, epiphenomenal, a symptom of the operation of purportedly more fundamental processes: Propp's patterns may be an effect of Freudian imperatives; Freudian imperatives, a result of the social dynamics of the upper-middle-class Viennese Jews who were Freud's contemporaries. Our choice among these patterns must be based not on their relative truth, a judgment we cannot make, but on the amount each contributes to the understanding of the ways in which rhetorical processes constitute science.

In his *Crisis of European Sciences* Edmund Husserl highlights the success of the natural sciences, a success to be contrasted with the general failure of reason in its task of improving the everyday world, the moral, mental, social, and physical space that all human beings share. Husserl locates this failure in the rupture caused by the dualism of Descartes. Whatever its source, the breach between the world of science and our human world is real enough, and the task of reconciliation is as pressing today as it was for Husserl. Because it sees science wholly as a product of human interaction, rhetoric of science is a gesture in the direction of such reconciliation, an argument for the permanent bond that must exist between science and human needs.

The question of whether rhetorical analysis is appropriate and equal to so formidable a task arises not as a consequence of any eternal truth or reasoned argument, but only as a result of the progressive narrowing and devaluation of rhetorical studies since Plato. It was Plato's successful attack on the Sophists that separated rhetoric from truth; it was the long authoritarian winter of the Roman Empire that limited rhetoric to its forensic and epideictic forms; it was the sterile intellectual reformulation of Ramus that reduced rhetoric to matters of style. That this narrowing was equally a degradation can be seen in phrases such as "mere rhetoric" or "empty rhetoric."

Turning our backs on this past, we can engage in a systematic examination of the most socially privileged communications in our society: the texts that are the chief vehicles through which scientific knowledge is created and disseminated. We can argue that scientific knowledge is not special, but social; the result not of revelation, but of persuasion. In this way we can see science as a permanent component of Husserl's life-world, where it has its origin, and from which it must obtain all its purpose.

CHAPTER 2

Analogy in Science

Chaim Perelman asserts that science "elaborates a system of necessary propositions which will impose itself on every human being, concerning which agreement is inevitable" (1971, p. 2). This opinion falls easily within the tradition of Aristotle, for whom the scientist is "proof against the persuasion of argument" (1960b, p. 519). To those with this view, scientific knowledge is privileged because it rests on a firm foundation—the bedrock of reality beneath a world of appearance. So unswerving a conviction could survive neither the no-man's-land of twentieth-century physics nor the rigors of twentieth-century philosophy. Indeed, this absolutist view of scientific truth now has an alternative, a sophisticated relativism in which truth depends not on conformity to a substratum of reality, but on agreement among significant persons. No theory of rhetoric in science can ignore this generally plausible relativism: since all truth is intersubjective, science, like all persuasive discourse, must convince us of the truth of its claims.

From a rhetorical point of view, the high esteem bestowed upon science gives its communications a built-in *ethos* of especial intensity. Ziman says that science has "tremendous *rhetorical* power . . . overwhelming persuasive force" (1968, p. 31); Douglas calls science "the most powerful rhetoric of all today" (1971, p. 57; see also Weigert 1970, Overington 1977, Brummett 1976, Kelso 1980). In this chapter I will clarify this special power of scientific rhetoric by focusing on some differences in the communication strategies of political oratory, scholarly argument, and scientific reports, differences based on the way these disciplinary domains use analogy.

I have chosen analogy for scrutiny because it is pervasive and revelatory. Analogy is traditionally a device central to rhetorical