ISSUES IN INTEGRATIVE STUDIES
No. 11, pp. 45-62 (1993)

Narrative and the Physical Sciences

by
J. Linn Mackey

Department of Interdisciplinary Studies
Appalachian State University, Boone, North Carolina

Abstract: A fable is presented that depicts a view of the situation of science in a postmodern world. This is followed by a brief account of how a foundationalist interpretation of scientific epistemology emerged. The attack on foundationalist views of science by the history of science, philosophy of science and sociology of scientific knowledge leading to Rorty's return to narrative is reviewed. Possibilities for a postmodern science are considered. Two examples from the new science of chaos are used to indicate that science is utilizing narrative-like approaches and is adapting quite well to a postmodern world.

Issac's Journey: A Fable

ONCE UPON A TIME, a premature and puny child was bom into a tribe of people. When it seemed clear that he would live, the child was named Issac. The people did not dream that Issac would embark on a great journey and bring the tribe one of its greatest and most useful treasures. You see, the way this tribe sought practical tools, devices, skills, wisdom, and guidance in running their common affairs was to send promising and adventurous young men and women on long hard journeys. The tribe did not specify where or how to go or what to bring back, but only that the travellers return with something of use or value. When those who took the journey returned, the tribe would all gather, listen to the story, and examine carefully what had been brought back. Some would return with a new type of food, some with a new technique, some with a dream, and some with words of wisdom. The tribe would carefully consider these, comparing them with what had been presented in the past. The tribe would then collectively decide what to add, adopt or modify for the common inheritance,

Issac grew to be a young man. He went to the elders of the tribe and said, "I want to take the journey for the tribe." The elders discouraged him, calling attention to his lack of physical strength and his widowed mother. But he persisted. Finally, the tribal elders said, "Issac has shown by his persistence that he does want to make a journey. Although he is not physically strong, he is extremely bright and talented. Let him go if he wants, but we will not expect much." At last the day came, and Issac departed on his journey. Eventually he returned, and the tribe gathered rather perfunctorily to hear of his trip. Surprisingly enough the tale of his journey was interesting. His journey had been difficult and long; like many journeys it involved a totem part of nature, in Issac's case an apple tree.

It is a journey worth telling, but now we must focus on its impact on the tribe. The most wondrous thing about the journey was what he brought back. It was a gem of immense beauty. The tribe had never seen anything like it. It was large and regularly shaped, and when one peered into its depths it revealed both answers to great problems and questions about which the tribe wondered—like how the moon and stars came to be in their courses—and how to build a device to keep time. The listeners were spellbound. It seemed to most that what Issac had returned with far exceeded anything brought back before, although several of the old tribe members argued that equally wonderful things had been given the tribe in the past. However, their voices were too few to convince the others.

Awed by Issac's gift, people spoke up to say that future adventurers should be encouraged to follow his path. This was done, and indeed some of those who did so found truly wondrous things while most of the others delivered less wondrous but still useful things. No one was prohibited from taking other journeys; it was just that the tribe paid them less heed. Grateful for Isaac's gifts (and in gratitude for those who followed in his footsteps), the tribe built a fine school to prepare and train others to follow his journey. Few of the tribe ever went inside the school, for only those who venerated Issac and were committed to preparing to copy his rigorous journey were allowed in.

Time passed, and the tribe fell on hard times. Issac's gift no longer seemed so useful or wondrous. Some of the things discovered by Issac's followers were instituted without full consideration by the whole tribe and had deleterious consequences. Different journeys had never ceased, and those who took them often returned with things the tribe again began to recognize as valuable. Debate broke out, some arguing that Issac's journey was not superior to any other, and some argued that the whole business was a waste of time since every journey yielded something, but the value of those products was always in dispute.

Finally a group of tribespeople who had taken different journeys decided to investigate Issac's journey, and they were shocked at the results of their investigation. They could find no reliable account of Issac's original expedition, even Issac's

original tale was found to be fabricated, and there was no likelihood that the true journey could be replicated. The preparation of Issac's followers had changed through time, and every journey they took was different.

It was concluded that in fact the journeys undertaken by Issac's followers were not all that different from other journeys. The tribe ended up back in a situation similar to where it was before Issac. People still attempted to follow Issac' s path, and they were accepted as no more special than those who took other paths. The tribe lived happily ever after.

Introduction and Overview

As this modest narrative may have suggested, developments in Western civilization have contributed an inflated epistemological basis to science. Science became the epitome of foundationalism. Recently the inflated epistemological claims of science have come under vigorous attack from the history of science, from the sociology of scientific knowledge, from poststructuralism and from philosophy. These attacks have been successful in some intellectual and artistic circles, but they have yet to make much impact on scientists and the general public. In time I suspect they will reach these audiences. In the language of my opening fable, the process which led to the re-valorization of journeys other than Isaac's is irreversible.

The resurgence of narrative in several intellectual areas is both a part of the attack on scientific epistemology and a sign of the attack's success. There is a search for less exalted, more human experience-based epistemologies. Narrative and narrative epistemologies fit this search well. But given the success of antifoundationalism, the rise of poststructuralism and postmodernism and narrative ways of knowing, what of the future of science? I will argue that even though the antifoundationalist attacks are succeeding (thus undermining the conventional epistemological basis of science), science can be understood on more intellectually modest grounds. I will further posit that recent developments in science have moved it in directions that show striking similarity to some narrative epistemologies. Science will remain an important component of and contributor to culture, albeit with diminished epistemological claims and lowered status.

The Emergence of a Foundationalist Interpretation of Scientific Epistemology

Foundationalism has been defined as "the establishment of a permanent and unique set of authoritative principles for human knowledge" (Toulmin, 1990, p. 56). It is not my intention to review the history of the rise of science and the emergence of foundationalism. 1 will simply say that the seventeenth century is important for both foundationalism and science and that Descartes and Newton were definitive figures. Most scholars agree that Rene Descartes was a key framer of the agenda of modern philosophy and physical science and a father of the modern foundationalist program (Toulmin, 8). At the center of Descartes' work was "the ambition to construct inherently certain and demonstrable foundations for metaphysics and the theory of knowledge" (Toulmin, 72). After Descartes, Newton—in his majestic *Principia*—provided one of history's premier examples of generalizations in science. His laws of motion, which could be written in a half page of mathematical equations, governed all the then known motions in the universe: falling apples, the motion of planets around the sun, spinning tops, the vibrations of musical instruments, the tides, the motion of waves in water, the transmission of sound through air and the flow of blood in veins and arteries (Goldstein & Goldstein, 1978, p. 198). Newton's achievement was immense and mesmerizing. It is understandable how the spectacular success of his generalizing convinced Western thinkers that his laws were *the* universe's and God's and that Newton's mechanistic model of the universe was not simply a model; *the universe was mechanistic!* In Alexander Pope's famous words:

> "Nature and Nature's Laws lay hid in night:
> God said, *let Newton be!* and all was light."

If we add to this the spectacular successes of modern science in medicine, the unleashing of nuclear power and the exploration of space, it is little wonder that science came to epitomize foundationalism. We have inherited what Philip Lewin calls mechanistic epistemology and the dream of monorealism. "Mechanistic epistemology seeks to enact the Cartesian dream of eventual acquisition of a single, complete representation of the world epistemically guaranteed through the rigor of scientific investigation. Mechanistic epistemology dreams the dream of monorealism: that (1) mechanistic science is the preeminent domain within which reason is exercised, and the epistemology of mechanistic science either simply is epistemology entire, or is our best example of an epistemology, insofar as epistemology is concerned with issues of truth and rationality; that (2) the scientific exercise of reason yields knowledge about the world that corresponds to the actual structure of reality; that (3) such knowledge is objective in the sense that it is true universally, and that all observers, once freed of their unfortunate biases, would recognize its truth; and (4) the different forms of knowledge revealed by the different disciplines cohere into a single consistent account of the nature of reality, and such an account collectively, if asymptotically, approaches a single, full and complete description of the universe" (Lewin, 1990). This view of science and scientific epistemology has come under serious attack in our time, but 1 suggest that it still is vigorously alive in many scientists, intellectuals and lay people today.

The Contemporary Attack on Foundationalist Views of Scientific Epistemology and the Return of Narrative

In this section I will survey some of the streams of antifoundationalist critiques of scientific epistemology. I will examine the history of science, the sociology of scientific knowledge and philosophy of science. Postmodern critiques are also important, but since they are considered in James A, Winders's essay in this issue, I will not deal with them. My treatment will be brief; however, it is important to outline the critical examinations of scientific epistemology, since this sets the stage for understanding "narrative and the physical sciences."

History of Science

I have the impression that until fairly recently the history of science was written by scientists with little formal training in history or by historians with little direct experience with science. This resulted in a view of science as progressively evolving toward an ever-closer representation of nature through a weII-definable scientific method that achieved positive knowledge of the world. In other words it confirmed mechanistic epistemology and monorealism. In the 1950's and 1960's a new generation of scholars emerged with previous experience in the natural sci nces, and when they turned their interest to the history of science, a veritable revolution occurred (Toulmin, 84-85). The seminal work in this new history of science was of course Thomas Kuhn's *The Structure of Scientific Revolutions* (Kuhn, 1962).

Kuhn had been educated as a physicist and experienced firsthand the education and practice of science before he turned to being a historian and philosopher of science. I suspect that when the full intellectual history of this century is written, Kuhn's book will stand out as one of the most influential works of our time. *The Structure of Scientific Revolutions* profoundly influenced the writing of the history of science and changed many perspectives about the nature of science and scientific epistemology. It also influenced developments in the sociology of scientific knowledge and the philosophy of science. Kuhn revealed a science starkly different from the traditional, progressive and foundational science assumed in the histories of science written before his. "In analyzing a science, it [*The Structure of Scientific Revolutions*] replaces *axiom systems*, which aspire to universal timeless validity, by *paradigms*, which are the creations of a given age or phase of science. It also substitutes for the dream of a singular *method*, applied across the board, the fact of plural explanatory *methods*, each of which is limited in scope and lifetime. In place of *formal* analysis of the logical structure of any scientific theory, as was aimed at by the positivist philosophers of Vienna in the 1920s, it relies on the historical analysis of diverse, variable concepts in different sciences, at different times" (Toulmin, 84). *The Structure of Scientific Revolutions* was itself a revolution in how science and scientific epistemology were viewed.

The Sociology of Scientific Knowledge (SSK)

SSK is a relatively new area of study. Ashmore claims it started in Britain in the early 1970s (Ashmore, 1989). Some important practitioners in the field are Barry Barnes and David Bloor from the Science Studies Unit at Edinburgh University; others include Harry Collins, Bruno Lator, Michael Mulky. and Steve Woolgar (Ashmore). Kuhn's work is an acknowledged influence on the field (Ashmore, 10). The field claims to be distinct from earlier sociology of science which treated the content of science as unproblematic. Practitioners of SSK believe that scientific knowledge consists of *people's* answers rather than *nature's* (Ashmore, 4). It is distinguished from philosophy of science and the work of epistemologists on the basis of its method, which stresses "original, first order, matter-of-fact, naturalistic empirical research" rather than what its practitioners consider the derivative, second order, speculative, and prescriptive approach (Ashmore, 5). Latour pioneered the "laboratory study" style of research wherein the SSK researcher goes to scientific laboratories and observes what occurs as scientists go about their work. In some cases the SSK observer functions as an anthropologist, studying scientists' day-by-day activities just as a Malinowski might study a band of aborigines in Australia or New Guinea (Knorr-Cetina, 1981).

A sizable literature has now emerged from the SSK. Ashmore summarizes the currently claimed implications:

> Sociology—the lowest of the sciences—promised to be able to explain the roots of credibility that sustain the self-evident and obvious as well as the True, Rational. Successful, Progressive pronouncements of natural scientific knowledge—whose status as *the* arbiter and standard for all other knowledge activities, including sociology, is still extraordinarily high, if not entirely unquestioned. If this kind of knowledge could be described as resting on no foundation more impressive than the contingent social circumstances of groups of interested—in both senses—human actors, then the consequences should be quite remarkable. For instance, such a conclusion would appear to warrant a reevaluation of the major epistemological thrust of Western philosophy since

> Descartes. Second, if physics can be explained by sociology, this threatens to invert the hierarchy of the sciences. (Ashmore, p. 7, 1989)

Philosophy of Science

In the philosophy of science of the early decades of the twentieth century, a resurgent foundationalism in the form of logical positivism emerged. According to Stephen Toulmin, "in the late 19th century, David Hilbert showed what a truly 'pure' mathematical system must be like. As a result, the system of formal logic and arithmetic built up by Frege and Russell was in the end even 'purer' than Euclidian geometry, which had served as Rene Descartes' model. The Vienna Circle program was, thus, even more formal, exact, and rigorous than those of Descartes or Leibniz. Freed from all irrelevant representation, content, and emotion, the mid 20th-century avant garde trumped the 17th-century rationalists in spades" (Toulmin, 159). Toulmin goes on to describe how after the publication of *The Structure of Scientific Revolutions* the walls between historians of science and philosophers of science collapsed, and by the mid 1960s professional meetings of both groups included sessions of common interest (Toulmin, 85). A vigorous attack on the foundationalist program of logical positivism resulted that included (in addition to Kuhn), Michael Polanyi, Paul Feyerabend and Stephen Toulmin. Ernan McMullin, reflecting on the current state of the philosophy of science in the mid 1970s, indicated how far that attack had come. He concluded that the foundationalist program of the logical positivists had been dismantled, and the very "rationality" of science threatened (McMullin, 1974, p. 668).

Why Narrative? is the title of a recent (1989) book coedited by L. Gregory Jones and Stanley Hauerwas. Why narrative? or more accurately why the return of narrative and what are the implications of this for the physical sciences? Having considered the contemporary attacks on the conventional views of science and foundationalist scientific epistemology, we are ready to address these questions. As Hayden White has said, "So natural is the impulse to narrate, so inevitable is the form of narrative for any report on the way things really happened, that narrativity could appear problematical only in a culture in which it was absent—or, as in some domains of contemporary Western intellectual and artistic culture, programmatically refused" (White, p. 244, 1987). It is clear that narrative was ruled out in many Western intellectual realms and that it has returned with a vengeance. I believe that the resurgence of narrative in several intellectual areas is both a part of the attack on an inflated, foundationalist scientific epistemology and a sign of the attack's success. There is a search for less pretentious, more human experience-based epistemologies.[1] Narrative and narrative epistemologies fit this search well.

Rorty and the Return of Narrative

I conclude this section with a look at the views of the contemporary American philosopher Richard Rorty. Rorty's position is directly relevant, for he both pronounces the death of foundationalism and moves on to narrative. In *Philosophy and the Mirror of Nature*, Rorty argues that ever since Plato, Western philosophers have been engaged in the futile pursuit of absolutely certain knowledge (Rorty, 1977). He then proceeds to make the pragmatist case against the idea that the mind is a faithful mirror of reality and that thoughts and language can ever accurately represent the "real" world. "Truth" should be viewed only in a pragmatic sense—i.e., that knowledge and theories are useful and work. "Truth is simply a compliment paid to sentences which seem to be paying their way," he has written (Klepp, 118). In Rorty's view, science has no monopoly on truth. "It is just one of many practical human inquiries (including politics, ethics, history, and art) that yield statements that either sustain themselves through further inquiry and experiment or fall by the wayside" (Klepp, 57).

In fact Rorty has a preference for narrative over philosophy and science. "Rorty has been busy maintaining that novelists and poets have more important things to tell us than philosophers do, that narrative is preferable to argument and theory and that philosophy, as traditionally conceived, is an empty and absolute game that might as well be called off (Klepp. 57). What we need are "storytellers whose writing gives examples of self-transformation, and poets and poetic philosophers who generate new metaphors for imagining ourselves" (Klepp, 123). Clearly, for Rorty foundationalism is dead. Science—the delivery of Isaac's journey—is demoted from its preeminent position in modern culture to one among other schemes for generating useful knowledge, and narrative is promoted to the place vacated by science as the most culturally valuable way of knowing.

I trust that the foregoing review of contemporary attacks on scientific epistemology with claims from the areas of history of science, the SSK and philosophy of science serves to make a case that the issue of narrative knowing and the sciences is significant. If one adds to these areas the critical assault on conventional views of science coming from deconstructive literary analysis,[2] one has an impressive array of different fields arriving at similar conclusions. Scientific knowledge has no privileged basis. It must take its place not above but alongside sociology and narrative knowing. Rorty perhaps poses the issues most starkly and dramatically.

What will happen if Rorty's views come to be generally accepted? What will happen to science with its foundationalist pretensions discredited, removed from its preeminent position in culture to one among many other pragmatically equal ways of knowing, and even superseded in its former preeminence by narrative? Bernard Williams has raised the possibility that science would cease lo exist under Rorty's pragmatist account of science as "one genre of literature." Scientists would no longer think their activity worth the trouble.[3]

Considering the Alternatives

What are some of the options at this point? One possibility is to defend the foundationalist account and justification for science and/or the premier place of science in culture. Perhaps Rorty and the other antifoundationalists are a mere passing cultural fad. It is probably true that most scientists and lay persons are not even aware of the antifoundationalist case. Even in academic circles the antifoundationalists are probably a minority and may remain so. Another possibility is to take Bernard Williams seriously. Rorty's reductionist account of science may win the day. As it spreads to scientists and the public, science will cease to exist. We may return to a state of culture similar to that before the rise of modern science, with fundamentalist religious foundationalisms in ascendency. Certainly those movements are astir in the contemporary world.

However, I am going to propose a different outcome to the antifoundationalist attack on science and the resurgence of narrative. I believe that although the antifoundationalist attack on science and that the return to narrative and narrative epistemologies are currently confined to a minority, they represent a gathering "postmodernism" that will triumph over the modernism which has foundationalist science at the center of its world view. Yet, I believe that science can and will survive the deconstruction of its traditional foundationalist justification and epistemology. I will argue that the less inflated and more humanistic understandings of science and scientific epistemology currently being fashioned will be adequate and even productive for a continuing "postmodern" science. Science will continue and even thrive in the emerging postmodern culture, albeit as one among other reasonable and useful ways of knowing.

Towards a Postmodern Science

Stephen Toulmin argues that there is another repressed source of modernity that our histories ignore in favor of the account of modernity with its origins in the seventeenth century and with Descartes and Newton as its godfathers (Toulmin, 1990). It will be recalled that the standard account places a foundationalist science at its center and leads to Lewin's mechanistic epistemology and the dream of monorealism. Toulmin argues that there is another form of modernity in the sixteenth century. Michel de Montaigne is a key figure, and the modernity that arises from this ground is more humanistic. "The culture of 17th-century Europe was transformed by changes that set aside the tolerance of late Renaissance humanism for more rigorous theories and demanding practices: these changes culminated in the new cosmopolis built around the forma! structure of mathematical physics. After 1750, that change was undone, bit by bit. The history of science and philosophy from 1650 to 1950 was not simply a triumphal procession of geniuses building on the work of their predecessors: rather, it had both light and shade, both an up and a down side. As the experience of humanity went through major changes, the presuppositions of the new cosmopolis were discredited, and by mid twentieth century the demolition was complete. At that point, thought and practice were free to return to the vision of the Renaissance" (Toulmin, 1990, p. 167).

Toulmin further argues that the natural sciences are already modifying in a more humanistic, less foundationalist direction. "In particular, the natural sciences, as they exist in the closing years of the twentieth century have come a long way from the mechanistic physics—or 'natural Philosophy'—that took shape in the 75 years after Descartes' manifesto in the Discourse on Method. Far from being formal systems based on abstract theoretical ideas alone, with a 'certainty' borrowed from geometry, today's sciences are deeply regrounded in experience; while increasingly, their practical use is subject to criticism, in terms of their human impact" (Toulmin, 181). With the return to a more humanistic modernism Toulmin sees "the return to the oral"—a renewal of concern among scholars for oral language, communication, rhetoric and narrative, "the return to the particular, the return to the local," "the return to the timely," a movement "from Leviathan to Lilliput," and a more human experience-centered reason supplanting the intellectually perfectionist, morally rigorous, and humanly unrelenting rationality of modern foundationalism (Toulmin, 188, 189, 192).

Thinkers like Alasdair Maclntyre, using the shared beliefs of traditions based on narratives (Maclntyre, 1988); Richard Bernstein, developing the notion of dialogical communities (Bernstein, 1983); and Lawrence J. Prelli, identifying the basis of a rhetorical logic (Prelli, 1989) establish human-scaled epistemologies for science that escape foundationalism and relativism. It seems to me that these epistemologies are more than adequate for the persistence of a postmodern science.[4] Science has a creative role to play in Toulmin's "humanized Modernity" or a postmodern world.

"Within a humanized Modernity," asserts Toulmin, "the decontextualizing of problems so typical of High Modernity is no longer a serious option. The axioms of Modernity assumed that the surface complexity of nature and humanity distracts us from an underlying Order, which is intrinsically simple and permanent. By now, however, physical scientists recognize as well as anyone that natural phenomena *in fact* embody an 'intrinsically simple' order only to a limited degree: novel theories of physical, biological, or social *dis*order (or 'chaos') allow us to balance the intellectual books. We may temporarily ['for the purposes of calculation'] shelve the contexts of our problems, but their complete resolution obliges us to put these calculations back into their larger human frame, with all its concrete features and complexities, . . . The seduction of High Modernity lay in its abstract neatness and theoretical simplicity: both of these features blinded the successors of Descartes to the unavoidable

complexities of concrete human experience" (Toulmin, 201). In the next and final section, I will show how contemporary science is already creatively adapting and usefully exploring the complexities of concrete human experience.

Narrative Knowing and the New Science of Complexity

I will now argue that the so-called new science of complexity or chaos has adopted a perspective that is in many ways analogous to the perspective of narrative epistemologies. I will show that with the new science of chaos, scientific epistemoiogy and narrative epistemology are very close if not the same. James Gleick in his book *Chaos* tells the story of the making of a new science (Gleick, 1987). Some say that twentieth-century science will be remembered for just three things: relativity, quantum mechanics and chaos (Gleick, 6). Although the new science traces its roots back to Henri Poincare, bom in 1854, the field really only emerged as a self-conscious entity in the 1970s. The first contemporary paper is generally attributed to Edward Lorenz and was published in 1963, but initially that work had almost no impact (Gleick, 31). A reasonable marker for the origin of the field would be the first conference, held in the summer of 1977. Approximately one hundred people came (Gleick, 184). Gleick says of the new science, "Chaos has become not just theory but also method, not just a canon of beliefs but also a way of doing science" (Gleick, 38).

The new science of chaos may be the first fully postmodern science because it explores the possibilities of human experience-centered ways of knowing. I will consider two specific aspects of chaos science to show its connections to Toulmin's humanistic science and to narrative and narrative epistomology. First, I will examine the way the science of chaos deals with equations called iteration; second, I will examine Shaw's classic dripping faucet experiment.

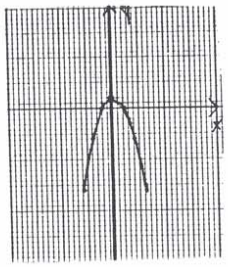
Iteration and a Human Experienced-Scaled Epistemology

One of the techniques and new ways of seeing the world developed by the new science of chaos is called iteration. This way of exploring equations represents a radical shift from the way most of us were taught. We learned to explore equations using Cartesian analytic geometry. Consider the simple equation

$$y = 1 - ax^2 ,$$

in which a is a constant. The Cartesian approach to this equation is to solve it, i.e., find the numerical values of x and y that satisfy the equation and plot them on a two dimensional grid. Let us take a = 1 and use the Cartesian approach. We try various values of x and find the corresponding values of y for $y = 1 - x^2$; we then plot these on a Cartesian grid to get

x	y
0	1
1	0
– 1	0
2	–3
–2	–3
3	–8
–3	–8



Our plot shows a parabola. In fact the equation $y = 1–ax^2$ from a Cartesian perspective gives a family of parabolas centered about the y axis. Note that our approach is Cartesian. We might expect that this way of approaching the equation is foundationalist. Let us see how this is so. In this approach to the equation there is no sense of time or process. We have taken a timeless view or a view beyond process. We are not constrained in our choices. We can choose any x and find the corresponding y. We can start with x small and work up or with x large and work down, or we can jump back and forth. The choices we have made in the past have no bearing on our future choices. We stand outside any contingency of choice. Given a modest set of points we can extrapolate the resulting pattern. It is surprise-free.

Contrast this with human experience. Our experience is temporal. We are trapped in time. Our present results from a specific inescapable past, and we sense we are in a process toward an indeterminate future. Note how different this is from the Cartesian approach described above. There is little vestige of the nature of human experience in the Cartesian approach to equations outlined above.

We now examine how the new science of chaos approaches the same equation. In this approach we write the equation as

$$X_{next} = 1–AX^2_{previous}$$

As Gleick explains: "When a number goes into the equation, a new number comes out; the new number goes in, and so on, points hopping from place to place. A point is plotted not when it satisfies the equation but when it produces a certain kind of behavior. One behavior might be a steady state. Another might be a convergence to a periodic repetition of states. Another might be an out-of-control race to infinity" (Gleick, 227). Let's try it out. Again I choose a = 1

$$X_{next} = 1 - aX^2_{previous}$$

Start with X = 0.

We have achieved a periodic repetition of states.

$X_{prev.}$	X_{next}
0	1
1	0
0	1
1	0

Now try starting with X = 2. You can see that starting with an X larger that 1 gives a process headed to infinity. The chaos scientist would say that infinity is an attractor of all points greater than 1.

$X_{prev.}$	X_{next}
2	–3
–3	–8
–8	–63
- - -	- - -
- - -	infinity

Now let's investigate the situation when a = 1.5 and start with X = 0.1. A calculator or computer helps. Wow, look what happens! We have chaos!

$X_{prev.}$	X_{next}
0.1	0.9850
0.9850	–0.4553
–0.4553	0.6890
0.6890	0.2879
0.2879	0.8756
0.8756	–0.1502

No one had ever seen what surprises lurked in such simple equations explored by iteration before 1971 (Gleick, 70).

If we compare the iteration approach to equations to the Cartesian approach and to human experience, we see the striking similarity of iteration and human experience. Once we make a choice of a and specific initial choice of X, we are caught up in an inescapable process. The past, in terms of our initial choices and their subsequent development, is significant. The process, once set in motion, moves to future states which are unknown until they are achieved. The process contains surprises like bifurcations, chaos and new states of order emerging from chaos.

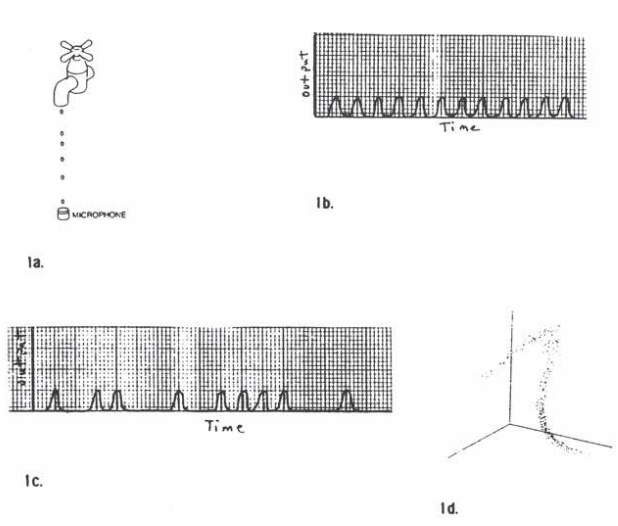


FIGURE 1. The Dripping Faucet Experiment

Crites, Shaw and the Narrative of the Dripping Faucet

I now want to turn to a "classic" study in chaos science. This is the now famous dripping faucet experiment of Robert Shaw and the Santa Cruz Dynamical Systems Collective.[5] [will compare the approach of Shaw and colleagues with Stephen Crites's classic in narrative studies of the narrative quality of experience (Crites, 1989).

The experimental set-up is very simple and is shown in Figure 1a. The sound of the drops striking the microphone (and the time of the drips) is recorded with time on a strip chart recorder. Initially, as the faucet is slightly turned on, the drops are very regular. (See Figure 1b.) As the tap is slowly opened, the drops become irregular. (See Figure 1c.) The time between the drops is irregular; it looks random. That is all there is to the experiment and data collection. We now turn to Shaw's analysis of the data, bearing in mind these words of Crites: "Consciousness grasps its objects in an inherently temporal way, and that

temporality is retained in *the unity of its experience as a whole*" (Crites, 73, my emphasis). Experience is temporal, but there is also more—there is *unity* and *wholeness*. The record of the faucet drops is a temporal record, a chronology of drops. Is there something more though, some unity in its whole? Crites goes on to argue that the present of consciousness exists as three modalities: a present of things past, a present of things present, and a present of things future. "The three modalities are correlative to one another in every moment of experience.... I want to suggest that the *inner form* [my emphasis] of any possible experience is determined by the union of these three distinct modalities in every moment of experience, 1 want further to suggest that the tensed unity of these modalities requires narrative forms both for its expression (mundane stories) and for its own sense of the meaning of its internal coherence (sacred stories). For this tensed unity has already an incipient narrative form" (Crites, 77).

Now we will examine how Shaw analyzed the dripping faucet data, his temporal record or chronology of drops.[6] He constructed a time series of the intervals between successive drips, e.g.,

1.73 1.92 1.67 1.24 1.83 1.56 1.11 1.25 -----.

He then created two additional time series by displacing the time values. We now have the original time series and two copies shifted one and then two places along, viz.:

1.73 1.92 1.67 1.24 1.83 1.56 1.11 1.25 -----.
1.92 1.67 1.24 1.83 1.56 1.11 1.25 -----.
1.67 1.24 1.83 1.56 1.11 1.25 -----.

We now have a set of triples:

1.73 1.92
1.92 1.67 -----.
1.67 1.24

Using a three dimensional coordinate system, each set of triples was plotted: e.g., 1.73 along the x-axis, up 1.92 on the y-axis, and 1.67 out on the z-axis, giving a point in space. When all the triples were plotted, Figure 1d results. If the data were truly random, the points should have been everywhere in the three dimensional plot. We see, in fact, that they are not scattered everywhere but are confined to a specific region in space. The data is not random; there is an *inner form*. The chaos scientist calls this inner form a "strange attractor."

I want to emphasize the similarity of Crites's notion of experience and what Shaw did. In creating the sets of triples, Shaw in a sense created the equivalent of Crites's three distinct modalities in every moment of experience. By displacing the time series, Shaw created points that bring together a present of things past, a present of things present, and a present of things future. Each triple contains a past, present and future. When these tensed modalities are plotted, an inner form (a strange attractor) is found in the nonperiodic dripping faucet. Shaw has revealed a kind of narrative of the dripping faucet. To say the least, there is a striking similarity between Crites's narrative analysis and Shaw's approach. Chaos science thus seems to be developing something very much akin to a narrative analysis in its approaches.

I have attempted to show in this section that science, in the form of the new science of chaos, is productively adapting and utilizing approaches based on human experience-based epistemologies.

Summary

In this paper I have looked briefly at the emergence of a foundationalist interpretation of science which gave science a preeminent place in culture. Antifoundationalist perspectives have emerged in recent times, and narrative and narrative epistemologies have returned. These movements signal the triumph of a radically revised modernism or even postmodernism. I have raised questions about the nature and place of science in such a postmodern society, arguing that science can and will survive and flourish with a more human experience-based epistemology. I have illustrated this by showing how the new science of chaos is already productively exploiting such a revised epistemology.

Biographical Note: J. Linn Mackey is Professor of Interdisciplinary Studies at Appalachian State University. He has a Ph.D. in Physical Chemistry and a Master's Degree in Social Ecology. A frequent contributor at AIS meetings. Dr. Mackey is currently working in the areas of fractal aesthetics and narrative interpretations of science.

Endnotes

1. A nicely organized and annotated but somewhat dated "Suggested Readings in Narrative Analysis" is given by Mishler (Mishler, 1986).
2. For example Ormiston and Sassower, 1989.
3. Williams' position is presented in Klepp, 1990, p. 124.

4. There are important differences between the postmodernism of deconstruction and Toulmin's humanized Modernity which need to be explored further.
5. Gleick gives a good account of the experience (Gleick, 263-267).
6. This is discussed by Ian Stewart (Stewart, 1989).

References

Ashmore, M. (1989). *The reflexive thesis*, Chicago: University of Chicago Press.

Bernstein, R. J. (1983). *Beyond objectivism and relativism*. Philadelphia: University of Pennsylvania Press.

Crites, S. (1989). The narrative quality of experience. In S. Hauerwas and L.G. Jones (Eds.), *Why narrative?: Readings in narrative theology*. Grand Rapids, Mich.: Wm. B. Eerdmans.

Gleick. J. (1987). *Chaos: Making a new science*. New York: Viking.

Goldstein, M. & Goldstein, I. (1978). *How we know: An exploration of the scientific process*. New York: Plenum.

Hauerwas, S. and Jones, L.G. (1989). *Why narrative?: Readings in narrative theology*. Grand Rapids, Mich.: Wm. B. Eerdmans.

Klepp, L.S. (1990). Every man a philosopher. *The New York Times Magazine*, Dec. 2, 1990.

Knorr-Cetina, K.D. (1981). *The manufacture of knowledge*. Oxford: Pergamon Press.

Kuhn, T. (1962). *The structure of scientific revolutions*. Chicago: University of Chicago Press.

Lewin, P. (1990). Honoring the word-soul. A paper presented at the meeting of The Association of Integrative Studies, Manchester, New Hampshire, Nov. 1-4, 1990.

MacIntyre, A. (1988). *Whose justice? Which rationality?* Notre Dame: University of Notre Dame Press.

McMullin, E. (1974). Two faces of science. *The Review of Metaphysics*. 27.

Mishler, E.G. (1986). *Research interviewing*. Cambridge, Mass.: Harvard Press.

Ormiston, G.L. and Sassower, R. (1989). *Narrative experiments*. Minneapolis: University of Minnesota Press,

Prelli, L.J. (1989). *A rhetoric of science: Inventing scientific discourse*. Columbia, S.C: University of South Carolina Press.

Rorty, R. (1977). *Philosophy and the mirror of nature.* Princeton, N. J.: Princeton University Press.

Stewart, I. (1989). *Does God play dice?: The mathematics of chaos.* Oxford: Basil Blackwell.

Toulmin, S. (1990). *Cosmopolis: The hidden agenda of modernity*. New York: The Free Press.

White, H. (1987). *The content of the form: Narrative discourse and historical representation*. Baltimore, MD: The John Hopkins University Press.