LABORATORY RITUAL: EXPERIMENTATION AND THE ADVANCEMENT OF SCIENCE

by Robert M. Geraci

Abstract. Technical achievement in laboratories requires millennia-old ritual formulations; the methodological expectations and presuppositions of scientists stem not only from investigations of the last three centuries but also from the ritual knowledge making that has governed human religion. Laboratory research is a form of human ritual open to interpretation in the manner of religious ritual. The experiments of the laboratory are fact-gathering ventures, but the integration of that knowledge into our general understanding of a universe of information networks is the process of knowledge making, and it is the highest achievement of all rituals, be they religious or scientific. Ritual theory offers insight into the nature of scientific experimentation.

Keywords: constructivism; experimental science; experimentation; knowledge making; information networks; internal realism; laboratory; pragmatic realism; quasi objects; realism; ritual theory; scientific advancement.

The laboratory is the home of modern science; it is the place where nature's secrets are revealed to us and where we learn to take control of once-hidden forces. Through rigorous laboratory research, scientists have condemned God to a place of obscurity and impotence and replaced the divine with technological achievement. What is the nature of this achievement, and what are the operating principles behind its development? How does the laboratory "work"? As we shall see, scientists relate to their research in a fashion that is millennia old—their methodological expectations and presuppositions stem not only from investigations of the last three centuries but also from the ritual formulations that have governed human religion.

Robert M. Geraci is a graduate student in religious studies at the University of California–Santa Barbara. His mailing address is 770D Cypress Walk, Goleta, CA 93117; e-mail rgeraci@yahoo.com.

[*Zygon*, vol. 37, no. 4 (December 2002).]
 ISSN 0591-2385

What do we gain from the laboratory? Why have we constructed this particular system of information gathering? The ritual of the laboratory has pragmatic value; with its system of examination and verification, it allows us to improve our method. According to French philosopher of science Michel Serres, highly "organized groups stress monitoring; it is no doubt desirable in the sciences and leads to rigorousness, if not to conformity" (Serres and Latour 1995, 85). Without doubt, the rigorousness of the scientific community (through laboratory research) has contributed to the many technological achievements of the modern period. We should not, however, assume that because the laboratory has helped push technology "forward," it holds some epistemological primacy. Philosophical approaches to information networks show us that the scientific enterprise cannot be wholly distinguished from other human endeavors. The nature of acquiring scientific knowledge is closely allied to other forms of information gathering, particularly religious ritual. Because of this, we must be careful to obtain a detailed understanding of how science functions within human activity.

Laboratory experiments help to ensure the ever-redeveloping technology of the modern age, but they also hearken to other, less rigid forms of behavior. Laboratory research is yet another form of human ritual; it is not immune to social influence or cultural interpretation. Ritual, according to Jonathan Z. Smith, is a "way of paying attention" (1987, 103). It directs our attention toward institutions and incongruities in the human experience; through ritual, we come to understand the role of particular identities in cultural networks. The experiments of the laboratory are knowledge-accumulating ventures—they increase our understanding of known conceptual frameworks. The integration of that knowledge with our general understanding of a universe of networks is the process of knowledge making, and it is the highest achievement of ritual behavior, including that of the laboratory. Knowledge manufacture builds the conceptual frameworks that are elaborated by knowledge accumulation. By examining the interaction of knowledge-making and knowledge-accumulating systems (without conflating the two), we gain a more advanced understanding of both science and culture. In order to understand how laboratories function, we must understand the relationship between science and other cultural phenomena, including religion. Then we will be able to narrow our examination to the laboratory alone and see how the ritual of experimentation epitomizes the relationship between knowledge making and knowledge accumulation.

Science exists within both cultural (human subject–oriented) and natural (object-oriented) networks; it is a social tool and, as such, is in some way socially constructed. In spite of that construction (or perhaps because of it), the scientific enterprise builds knowledge of the way in which the world functions and allows us a glimpse into the ways that networks of reality exist. This very dichotomy between subject and object must be called into question in the light of recent philosophical discussion, and the course of that examination will further affect our understanding of the observer and observed. Scientific knowledge does not exist outside of a human knower—every scientific theory or piece of laboratory equipment exists relative to the ways in which it has been discovered, invented, and employed by human beings. Without understanding this, we cannot effectively grasp the nature of science or the way that it interprets the world. Science is based upon such human faculties as interpretation and faith and is therefore akin to certain religious exercises. This is not to say that science is nothing but ersatz religion; rather, science, like religion, makes use of the inherent capabilities and methods of the human mind, which allows us to draw certain parallels between them. Using a variety of modern, postmodern, and "nonmodern"[1] philosophical examinations, the next two sections demonstrate how science functions within cultural networks more broadly construed. Then, in conjunction with contemporary scholarship into the nature of religious ritual, we shall see how the laboratory is the home of scientific ritual that cannot be simply or easily distinguished from religious ritual in form (though not content!). Both forms of ritual serve to advance human knowledge and provide significant opportunity for human beings to interact with and understand their world.

Science in Cultural Networks

Science and Society. According to Steven Shapin, the laboratory, thanks to the separation of science and society, has existed in a cultural vacuum. The lab is a place where only the laws of physics apply,[2] a place where common experience is replaced by a purified system of knowledge accumulation. Increasingly sophisticated and accurate mechanical models led scientists to the belief that our experience of the world has little to do with the way it really operates. For those philosophers,

> The distinction between primary and secondary qualities, just like the Copernican view of the world, drove a wedge between the domain of philosophical legitimacy and that of common sense. Micromechanical reality took precedence over common experience, and subjective experience was severed from accounts of what objectively existed. Our actual sensory experience, we were instructed, offered no reliable guide to how the world *really was*. (Shapin, 1996, 53)

As commonsense experience was devalued in the scientific realm, so was the influence of that experience upon scientific inquiry. Thus, while scientists correctly found that their experiential world could be re-modeled mathematically and conceptually to dismiss many common observations, they incorrectly assumed that this meant they could produce scientific research in absence of cultural influence. The advice of such philosophers was that "if you really want to secure truth about the natural world, forget tradition, ignore authority, be skeptical of what others say, and wander the fields alone with your eyes open" (Shapin 1996, 69–71). Implicit in these directions is that it is possible to follow them. This outlook has produced the modern expectation that represents "*what is* in the natural world, not *what ought to be*. . . . Science, in this account, fails to report objectively on the world—it fails to *be* science—if it allows considerations of value, morality, or politics to intrude into the processes of making and validating knowledge. When science is being done, society is kept at bay" (1996, 162). The very nature of science, for Shapin, is the separation of knowledge and values, knowledge and culture. In this view, science endeavors to explain a world that exists without human interaction—it is the world of "real" physical events that exist prior to and without regard to human observation and interpretation.

Although scientific discourse often concurs with this description of its own distinction, we must account for the fact that scientists, themselves, do not exist within a cultural vacuum of any sort. According to anthropologist of science Bruno Latour, "the very act of perception is constituted by prevalent social forces" (1986, 33). We see, therefore, that scientific inquiry is directly tied to its social context; this applies to the discovery of new technologies as well as to the refinement of those already existing. Historically, it is almost impossible to conceive of the atomic bomb without a world that is searching for it, even if that search is misconceived. It was precisely the need to exploit atomic energy as a weapon that led to the Manhattan Project and the Los Alamos discovery.

Many scientists rest in the belief that science can be distinguished from the values, beliefs, and interpretations of its community. Certain questions must be raised, however, before we accede to such a perspective. Given that science cannot be so easily removed from cultural interactions, we should attempt to find the specific interactive forces that govern scientific research. We must isolate, insofar as we can, the ways in which science is a human (cultural) tool. Clearly, laboratory experiments are not equivalent to a night out on the town or to debates in the Senate, so what are they? Under what rules does the laboratory act?

Science and Faith. While mistaken assumptions about the nature of scientific experiment have clouded our perception of cultural phenomena, a new appreciation for knowledge making shows us that ritual experiment is integrally tied to cultural development.[3] We now understand that science cannot be placed on a golden pedestal, separate from culture and absolute in its method and content, but we have yet to show how science should be perceived in relation to its context.

Science, as a knowledge-making venture, is subject to certain requirements of human operation. In "Faith and Knowledge: The Two Sources of 'Religion' at the Limits of Reason Alone," Jacques Derrida emphasizes the fiduciary requirement of all truth claims. He says that "the 'lights' and Enlightenment of tele-technoscientific critique and reason can only suppose trustworthiness. They are obliged to put into play an irreducible 'faith', that of a 'social bond' or of a 'sworn faith'" (Derrida 1996, 44). In discussing scientific knowledge, we assume that there is some basis for the knowledge that we gain through experiment. Moreover, when one individual passes information to another, it is essential for both to assume the basic creditworthiness of the source; this fact is vital to understanding the network of functions between community and ritual.

In ritual, as Victor Turner points out, the "community is the repository of the whole gamut of the culture's values, norms, attitudes, sentiments, and relationships. Its representatives in the specific rites—and these may vary from ritual to ritual—represent the generic authority of tradition" (1969, 103). Even in the most refined of scientific endeavors, one must be prepared to accept certain authoritative claims without challenging them. Scientific study requires that one accept certain preestablished theorems and facts in order to begin research. "From the standpoint of the individual the interpretive traditions of science are largely inherited from others, shared with others, validated by others and sustained in the course of interacting with others" (Barnes, Bloor, and Henry 1996, 26).

Thomas Kuhn's concept of paradigm gives us the theoretical sophistication to describe how scientific predilections exist prior to any given individual's appropriation thereof: "Observation and experience can and must drastically restrict the range of admissible scientific belief, else there would be no science. But they cannot alone determine a particular body of such belief. An apparently arbitrary element, compounded of personal and historical accident, is always a formative ingredient of the beliefs espoused by a given scientific community at a given time" (Kuhn [1962] 1996, 4). This "accident" situates a scientist within a social network that necessarily influences his experiences. Because of his emphasis upon observation, a scientist can eventually overcome the "stacked deck" of previous experience, bias, and authority that he has been dealt, should those preexistent systems prove repeatedly unable to answer scientific questions. Nevertheless, scientific practice necessarily involves using the network into which one has been placed in order to further discovery.

This network (paradigm) consists of known facts, theoretical models, and observational techniques (and technologies) as well as observable events. The scientist must master these things conceptually and technically; he must be able to make use of his paradigm in creating scientific knowledge. He cannot be expected, however, to have begun from scratch and proven each and every aspect of his model. Rather than reinvent the wheel, students are encouraged to understand the conceptual bases of their scientific fields but not to challenge every single authoritative statement. Since the Scientific Revolution, according to Shapin,

> despite much rhetoric preferring the authoritative testimony of things to that of people, the modern enterprise *in no way* dispensed with reliance on human testimony, nor is it possible to imagine what a natural scientific enterprise that wholly rejected testimony would look like. Modern practitioners were supposed to acquire a stock of factual knowledge, but most of that knowledge was necessarily acquired at second hand. (1996, 87)

Scientists necessarily must trust certain information that is handed to them preformed by years of scientific inquiry. Naturally, a chief task of the informed and skilled scientist is to discriminate among sources. Among the scientist's repertoire of skills is the ability to differentiate reliable sources from unreliable. Once she has made such a decision (or it has been made for her), however, she must have a certain amount of faith in that knowledge.

In addition to trusting that our body of factual information is reliable, we must assume that our method of questioning is also reliable. There can be no question of the genuine (if only theoretical) ability of the scientific method to calculate the nature of the world, or we have lost the entire system's utility. Because of this, "we speak of trust and of credit or of trustworthiness in order to underscore that this elementary act of faith also underlies the essentially economic and capitalistic rationality of the teletechnoscientific. No calculation, no assurance will ever be able to reduce its ultimate necessity, that of the testimonial signature" (Derrida 1996, 45). The testimonial assures us that knowledge is real, that it is knowable. There is no evidence, per se, that knowledge has any ontological status whatsoever—we must have faith that there is some kind of knowledge and, moreover, that knowledge is transmittable not only by us but to us.

Many would prefer to believe that the information, the appearances, saved by science indicate that system's total validity, but they do so only in the fiduciary act that encompasses knowing. "The temptation of knowing, the temptation of knowledge, is to believe not only that one knows what one knows . . . but also that one knows what knowledge is, that is, free, structurally, of belief or of *faith*—of the fiduciary or of trustworthiness" (Derrida 1996, 31). Fundamental to a proper understanding of science—one that incorporates a comprehension of the network of relations and demonstrates exactly how the scientific enterprise functions in human knowledge making—is overcoming this temptation. Philosophy and science alike must learn to examine and express the ways in which belief informs our scientific knowledge even as it informs our religious faith.

Our scientific reason attempts to present itself as the ultimate authority over the experienced world. Because what we do in the laboratory is duplicated in the larger world (and vice versa), we assume that the information thus presented is foundational and self-sufficient. Derrida says, regarding faith and knowledge, that "between believing one knows and knowing one believes, the alternative is not a game" (1996, 40). The interaction of belief and knowledge is not one of antagonism or conflict but rather opposition in the sense of the opposable thumb, by which, to use William H. Bragg's sensibility, things are grasped (Bragg 1920, 195–96).[4] When we look deeper into this dilemma, we begin to see how our belief provides the foundation for systems of knowledge—for experimental science but also for culture (including religion).

Derrida approaches religion and science as though they were distinct and then seeks to understand how the two relate. According to him,

> religion and reason have the same source. . . . Religion and reason develop in tandem, drawing from this common resource: the testimonial pledge of every performative, committing it to respond as much *before* the other as *for* the high-performance performativity of technoscience. The same unique source divides itself mechanically, automatically, and sets itself reactively in opposition to itself: whence the two sources in one. This reactivity is a process of *sacrificial indemnification*, it strives to restore the unscathed (*heilig*) that it itself threatens. (1996, 28)

By this, we see that religion and reason (science) have segregated themselves in order to preserve themselves. Science seems to have divorced itself from other human systems in order to establish its own authenticity; it must do this, or it will suffer from continuous comparison of similarity. That scientific reason shares its origin with religious belief is not an attack upon science. It does not impinge upon science's knowledge-accumulating and knowledge-making capacities; it is not to say that science and religion (or other cultural forces) have equivalent or identical capacity to disseminate information. Rather, science asks different questions and receives different answers than other aspects of culture building, but it remains a part of the cultural network.

Our faith in the performative faculty of science gives us cause to expect results from many of its endeavors and to lend credence to its discoveries. We cannot dismiss science as irrelevant simply because it lacks ontological priority. In a world without such privilege, we must accept what pragmatic impact there is to be found from varying resources. Our networks of information transfer allow us to accept pragmatic realism, if not ontological realism. That is, pragmatic realism (or internal realism) allows one to be "*both* a realist *and* a conceptual relativist" in that one can accept how the facts gleaned from scientific exploration function within our information networks without requiring an unprovable metaphysical realism (Putnam 1987, 17). According to Hilary Putnam, there "are 'external facts,' and we can say *what they are*. What we *cannot* say—because it makes no sense—is what the facts are *independent of all conceptual choices*" (1987, 33). The information content of the sciences has immense pragmatic value, but its value is limited if we do not appreciate the origins of that value and thereby its limitations. Realism must be internal to the information schemata that explore the world—it cannot be assumed to exist outside of the means and methods of that exploration without a leap of faith untenable within the position itself. The scientific enterprise, including laboratory performance, exists within conceptual constructs, whether we call those constructs paradigms, predilections, research programs, or networks. In order to fully grasp the function of the laboratory—and science more widely—within such networks, we must understand how the networks themselves work.

Mediation of Phenomena

We look for the underlying assumptions of science in a cultural context only so that we can properly understand how those assumptions affect our comprehension of scientific knowledge making. Science certainly creates knowledge; ritual experiment does describe the actions of nature and allows for increasingly accurate predictions of natural events. But what can we say about the relationship between the laboratory and culture? The laboratory does not exist independently of its context; we have seen through the fiduciary act that it cannot be separated from other cultural phenomena. Indeed, the laboratory must be considered nothing more than one among many such. The laboratory does not hold a privileged place in our constructions, even though it does hold a specific one.

Latour briefly describes the paradox of modern humans thus: "They have not made Nature; they make Society; they make Nature; they have not made Society; they have not made either, God has made everything; God has made nothing, they have made everything. There is no way we can understand the moderns if we do not see that the four guarantees serve as checks and balances for one another" (1993, 34). Latour recognizes that we have sought to distinguish our experimental sciences from our sociopolitical sciences; they have gained strength and force from that separation because we have not invented them, yet we are able to define the way they behave. Only when caught with a contradiction between science and culture (as invented by human beings) do we now resort to God as a mediator, either in God's transcendence or God's absence. Attempts to describe the world have variously sought to situate science squarely within the imagination of men or as totally independent of human ingenuity (pure constructivism or pure realism). In both cases, a sense of how science acts within the human experience has been completely lost. The thrust of research into the nature of science is to describe precisely how it fits into the further network of human actions, knowledge, and interpretation.

Because the prior understanding of science has necessitated that we remove it from its human context, if we are to reassert the interdependence of science and culture we must find a language for discussion. The laboratory offers us such an example. According to general practice, the lab is a place of reductive analysis—in the lab, we break down objects into individual constructing phenomena. In *Angels: A Modern Myth* (1993), Serres emphasizes the dangers of this approach by demonstrating that reductionism can eliminate the necessary information of the network. His protagonist claims that when "a patient tells me that he has a pain, he points to a particular part of his body where different tissues, cells and functions intermix. You never tell me anything about that place. . . . In the laboratory you lose life: in my case life requires of me that I comfort and save it" (p. 285).

The lab breaks down the physiognomy, leaving its physical components bared to scientific observation; laboratory analysis leaves out the crucial aspect of pain, the experience of pain itself. Serres, an advocate of information networks, insists that one cannot simply reduce the system to a world of individual particles, of constituting principles; to do so is to lose sight of the networks that they construct and that, in return, construct them. Laboratory experiment provides us with a product that cannot truly be isolated from its initiatory conditions. The laboratory itself is a component of information and activity networks, as we see in the next section. Latour's restructuring of the subject-object dichotomy provides a critical new perspective on the role of the lab in such networks.

The strength of Latour's method rests in its ability to incorporate both the human aspects of observation and the independent object being observed. Latour's axes conserve the facts of the "real" world without giving them metaphysical priority over their "social" counterparts. Latour uses a language of quasi objects (which are simultaneously quasi subjects) to describe "experiences." Rather than seeking to push objects far into the corner of objectivity or their commensurate descriptions into culture-specific subjectivities, Latour develops a method of continua for explanation. Quasi objects, such as a measured vacuum, "exist" in several forms: (1) the measured event, (2) the measuring device, (3) the vacuum measured, (4) the concept of vacuum independent of any actual vacuum, and (5) the objective vacuum that exists outside of conceptual designation. These five vacuums can be plotted on axes of object-subject (nature-culture) and existence-essence (reality-conceptuality); such continua are obvious within the defined vacuums, as is the positionality of vacuums in question (Latour 1993, 85–88).

A vacuum is a "thing" we measure, but it is also a concept we invent; simultaneously both, it is neither independently one nor the other. All things can be measured through their mediators, according to Latour. They become networks of understanding; but rather than allowing such networks to become incomprehensible by destroying the mediated, Latour uses his axes of continua to describe them. In his work, we find "an Ariadne's thread that would allow us to pass with continuity from the local to the global, from the human to the nonhuman. It is the thread of networks of practices and instruments, of documents and translations. . . . The only difference [between network and locality] stems from the fact that [networks] are made up of hybrids and have to mobilize a great number of objects for their description" (1993, 121).[5] By using a grid of objects to describe each independent object, the described can be seen more completely than when one seeks to isolate it "in itself."

Latour maintains the particulate while examining its role in information systems; this allows him to tread across the difficult ground of conceptually unifying scientific and cultural knowledge. The laboratory, itself, fits into Latour's continua as (1) a place being used, (2) the specific place, (3) the use to which it is put, (4) the concept of such places, and (5) the nature of its usage, even before it is used. The laboratory is a quasi object and is mediated by its ritual use. The experimental world of the lab demonstrates the complex relationship between the real and ritual worlds. It mediates knowledge by grasping the complex interrelations of knowledge accumulating and knowledge making in the laboratory, which are accomplished through a ritual modality—the laboratory is the quintessential place and process of networking information.

We seek to understand the mediation of phenomena because without such an understanding our knowledge is limited (though it is socially mandated in that form). As Serres points out, "Hemiplegic bodies have granted each other recognition and force everyone to remain in the stupid pathology of division" (1997, 4). Phenomena become real through mediation. When we seek to make them independent of their networks, we lose them to illusory constructs. Problematically, it "is easy to understand why houses and cars and baskets and mugs are at once *fabricated* and *real*, but this is of no help in accounting for the mystery of scientific objects. It is not just that they are both made up *and* real. Rather, it is precisely *because* they have been artificially made up that they gain a complete autonomy from any sort of production, construction, or fabrication" (Latour 1999, 127). Insofar as we understand how objects are mediated we gain a more complete understanding of the objects themselves. Objects are real because they are inclusive, because they relate to one another in mediated networks.

A system of knowledge that excludes the capacities and understandings of its correlate fails to know at all. Rather than function within Serres' epidemic hemiplegia, we must direct our learning to a coherent integration of knowledge. As we shall see, the laboratory is the perfect starting point for the reintegration of science into a larger framework of human knowledge making. Without losing sight of experimentation's performative and predictive capability, we can still see how it functions within networks of interpretation, learning, and comprehension through ritual activity.

Ritual Experimentation

Laboratories are homes of ritual. Just as temples serve to house the interpretive activities of humans, laboratories are places not only of knowledge accumulation but also of integration—places where knowledge making occurs. What defense can there be for the claim that the actions of the modern scientist are in some way equivalent to those of the tribal shaman or the temple priest? Laboratories are places of ritual experimentation. How are we to look at ritual if we are to make such a case? We shall not begin by developing an identity between priestly ritual and scientific ritual, because there is no such identity to be found. When we declare that the scientist's actions mirror that of the priest, we claim only a methodological significance. It is not our purpose to assert the identity of either the presuppositions or the results of scientific and religious activity. Rather, we would like to see how ritual functions within the human context and then apply that to scientific experimentation to determine how, if at all, the laboratory is home to ritual behavior.

The content of science can, loosely speaking, be determined quantifiably, verified interpersonally, and falsified according to reason and observation. According to Martin Heidegger, the "objectifying of whatever is, is accomplished in a setting-before, a representing, that aims at bringing each particular being before it in such a way that man who calculates can be sure, and that means be certain, of that being" (1977, 127). Scientific content requires a certain calculation and objective determination in order to reach conclusions. The content of religion does not necessarily accept such necessity, but similarly, the content of religion cannot always accomplish its goals as effectively and (sometimes) unequivocally as science. Although religion and science differ in their information content, they share the significant characteristics of particulates embedded in mediated networks. Moreover, there are similarities of form between the scientific and religious enterprises. Ritual action and interpretation is key to knowledge-making ventures of scientific as well as religious nature.

If we are to demonstrate the ritualistic aspects of laboratory work, we must first define the nature of our inquiry and then apply that answer to our present context. In his seminal work on ritual in religion, Smith says,

> Ritual is a means of performing the way things ought to be in conscious tension to the way things are. Ritual relies for its power on the fact that it is concerned with quite ordinary activities placed within an extraordinary setting, that what it describes and displays is, in principle, possible for every occurrence of these acts. But it also relies for its power on the perceived fact that, in actuality, such possibilities cannot be realized. (1987, 109)

Smith recognizes here a defining characteristic of ritual that is easily ignored in both religion and science: everyday experience and ritual are distinct. Scientific inquiry, in order to inform us of anything specific and useful, relies upon its control over the variables. In other words, if we wish to determine aspect *A* of phenomenon *P*, we must isolate as many other aspects (*B*, *C*, *D*, etc.) of the phenomenon as we can and control them. When we remove variability from these characteristics, we are able to test the result of variability in *A*, the object of our inquiry. If we want to know the effect of a certain chemical upon the human body, we homogenize aspects of our test subjects to the maximum possible extent; this control of the variables is essential in order to be sure that effect *X* is the consequence of variability in *A* and not some other aspect of the test subject.

When we organize a laboratory test, we do so with the recognition that our test is being performed in a manufactured way. That is, nothing occurs in the laboratory as it does outside of it. "In fact, one rarely works in laboratories with objects as they occur in nature. Rather, one works with object images or with their visual, auditory, or electrical traces, and with their components, their extractions, and their 'purified' versions" (Knorr Cetina 1999, 26–27). Electrical discharges may occur both in and out of the lab, but by isolating variables we change the network of possible interactions. We reduce the world of possible influences and interactions and then generalize our results to the entire world in spite of the inherently more complex nature of that world. Both experimentally and theoretically, scientific ritual makes use of a world exempted from the ordinary network of experience. "As an example of *an imaginative new concept*, consider Galileo's idea of motion without air resistance (which was the key to the principle of inertia). His contribution here was no mere 'careful observation' but a conception of the world as we do *not* experience it" (Barbour 1997, 11). The scientific enterprise requires the utilization of our imaginative capabilities; moreover, it requires that we be able to direct our attention away from the world as we ordinarily experience it to a constrained world that we have imagined and created (even though that world is not "manufactured" in the sense of a car).

Scientists acknowledge that the world of the laboratory is not the real world, but they believe that every reaction that takes place in the laboratory could just as well have taken place in that real world. According to Shapin, this belief arose during the sixteenth and seventeenth centuries, as scientists began to analyze and critique, in earnest, the orthodox beliefs of the Roman Catholic Church. In order for their results to be valid, however, the philosophers of the time had to assume that their experiments held as specific examples of generalized principles: "It was not just that the imperfections and changeability of things on earth could be recruited as resources for understanding celestial phenomena; modern natural philosophers also claimed that earthly effects *artificially* produced by human beings could legitimately serve as tokens of how things were in nature" (Shapin 1996, 18–19).

We cannot use the laboratory to describe a "true reality," because the laboratory does nothing but construct very specific realities in which to test its subjects. The notion of a real world outside of human experience further fails to take into account the very networks that we have seen to determine that reality's existence. There is no reality outside of a network of interactions. As Putnam says, "Internal realism says that the notion of a 'thing in itself' makes no sense; and *not* because we cannot know the things in themselves. . . . Internal realism says that we don't know what we are talking about when we talk about 'things in themselves'" (1987, 36). There is no reality to describe outside of an interactive network. Networks of relations are precisely the reality that we all experience.

The laboratory would be useless, however, if it sought to actually simulate "reality-in-itself"; fortunately, it does not even attempt to do so. The laboratory creates an artificial environment where we can test only certain principles, those of greatest immediate interest. "The ritual is incongruent with the way things are or are likely to be, for contingency, variability, and accidentality have been factored out," but it nevertheless allows us to construct a system of knowledge (Smith 1982, 65). We construct and accumulate knowledge precisely by not imitating any reality-in-itself in which we may believe. By fabricating a network, we learn how objects (quasi objects, in Latour's language) function within networks as a whole. We do not invent relationships, but we do invent the relators.

The genius of the scientific method, which is dramatically underplayed by scientists themselves, is the ability to take information that we know to be constructed and generalize it to an entire system, which we have not constructed in any conventional sense (rather, we have been situated within it and without our control). The scientific method gives us the ability to resolve the difference between the accidentally experienced world and the ritually constructed laboratory world. Unfortunately, an emphasis upon saving the appearances of research can be counterproductive through the attempt to dissolve as many of science's subjective characteristics as possible. In science, "Constructivism, when it multiplies intermediary steps, seems always to *weaken* the claims to truth, to destroy the object under scrutiny" (Latour 1998, 423). All too frequently, the scientific method assumes the necessity of simplified descriptions. That is, scientists weed out any subjective or creative elements in their work, professing that the research stands for itself. "It is essential that a tiny core of information escape from the setting and let you ignore the rest"; in science, you "cannot, as in a performance, be constructivist and realist at once, even though you know pretty well . . . that you have 'constructed' your data" (1998, 424). Laboratory ritual demonstrates how a certain kind of constructivism can be admitted into science, destroying the utility of those very rituals. Knowledge is manufactured in the laboratory according to a set of relations that define the entire network—it, knowledge, cannot exist without the network that frames it.

Ritual acts as the safeguard of reliability. Roy Rappaport has described the means by which the sacred emerges from liturgical invariance (1979, 208–11). Within these networks, experiments are designed with invariance as a measurement of truth. This truth, moreover, extends beyond the confines of its original temporal location. Rappaport says "that which occurs in liturgical time out of time is characterized by punctilious repetition *and is thus represented as never changing*" (1992, 15). The eternal aspect of liturgical truth closely, if not perfectly, resembles the transtemporal assumptions of scientific laws: the law of thermodynamics, for example, once elucidated, was assumed to have been operational prior to its own "discovery." The laws described in the laboratory, the effects that take place therein, these are, like liturgical events, characterized by endless, unchanging repetition.

Should the "relators" be correctly aligned, the experiment will yield the desired results. Truth takes on the power of the sacred through ritual, be it scientific or religious. Certainty, according to Rappaport, arises from invariance of religious ritual. It does so likewise in scientific ritual. The certainty of a scientific claim is, in at least some way, proportional to its invariance over the course of time.

The worldview of many scientists assumes that scientific work is objective and factual, without subjective interpretation and analysis. Though truth and degrees of certainty may continue in science, this particular assumption must be challenged. Scientific research, in fact, is the subject of specific subjective decision making. The kinds of questions that scientists ask are determined by social needs, language, and conventional expectations. By no means does this invalidate the questions or the answers that scientists develop; although science relies upon a subjective perspective, it would be the height of foolishness to describe its accomplishments as purely subjective or as cultural illusions. We should accept, however, that science, like all human endeavors, is an experiential phenomenon, one that is developed (constructed) by human expectations, observations, and inspirations. Like ritual in religion, ritual in science suffers from the fact that "*ritual is an exercise in the strategy of choice*. What to include? What to hear as a message? What to see as a sign? What to perceive as having double meaning? What to exclude? What to allow to remain as background noise? What to understand as simply 'happening'?" (Smith 1982, 56)

When data are observed, scientists seek to conserve that data as well as possible. They take note of their observations and then make conclusions. Often, however, humans ignore data or reinterpret it to fit existing theories. According to Latour, "epistemological qualities of validity or wrongness cannot be separated from sociological notions of decision-making" (1986, 121). Even the greatest scientists are not immune to this. Albert Einstein, for example, mathematically predicted the expansion or contraction of the universe in his theory of relativity. Because he was confident that the universe was static, however, he adjusted his data (not his theory) with the now quite famous cosmological constant. It wasn't until the astronomer Edwin Hubble discovered the redshift in 1929 that the expansion of the universe was accepted, and Einstein admitted his error. Although this error was rectified, it is clear that scientists' preconceptions can influence their "conservation" of the data.

It is not actually science's weakness but rather its great strength that it is able to resolve this conflict between ritual and reality. As Smith notes about ritual, "now one is obligated to find out how *they* resolve this discrepancy rather than to repeat, uncritically, what one has read. It is here, as they face the gap, that any society's genius and creativity, as well as its ordinary and understandable humanity, [are] to be located. It is its skill at rationalization, accommodation, and adjustment" (1982, 62). According to Serres, what "makes for an advancement in philosophy, and also in science, is inventing concepts, and this invention always takes place in solitude, independence, and freedom—indeed, in silence" (Serres and Latour 1995, 37). It is the creative act of knowledge making, not merely the ritual act of knowledge accumulating, that constitutes advancement. "New concepts are the product, not of precise observation or of mathematical deduction alone or even of the two together, but of creative imagination" (Barbour 1997, 17). By developing a coherent understanding of the relationship between the world of the laboratory and the world outside it, scientists and philosophers of science, in their respective disciplines, construct a cohesive worldview, one that can take account of cultural as well as natural influences. Their accomplishment is to discern the relationship between humans and the environment. Interpretation of ritual is knowledge making, and it excels beyond mere accumulation of information; the ritual nature of experimentation—of the laboratory—makes this interpretation possible.

Knowledge manufacture, through ritual, is an ongoing process. Though metaphysical realism requires that a static truth be discernible, an internal realism is compatible with network theory. As new information acts within the network, the world itself changes. Because of this, the comprehension of truth becomes a continuous project, one of institutionalized liminality. In his classic work, *The Ritual Process*, Victor Turner describes liminality as the state "betwixt and between," where passage from one position to another takes place (1969, 95). The liminal person "must be a *tabula rasa*, a blank slate, on which is inscribed knowledge and wisdom," says Turner (p. 103). Humanity exists perpetually in this state. The ritual of experimentation is one way in which knowledge is obtained; that such knowledge is only transtemporal according to an internal standard of consistency does not affect its impact upon humans. Though the network is ever-changing, the information accumulated "is not just an aggregation . . . it has ontological value" (p. 103).

Ritual is perpetually liminal and yet defines truth and certainty through its perpetuity. By directing the scientist's attention toward certain facts and by resolving the conflict between reality in the laboratory and reality in the casually experienced world, the scientific method points us toward truths that are somehow both transhistorical and immanently embedded in cultural and temporal networks.

CONCLUSION

Laboratories are the utopias, the nonplaces, of information. The knowledge within them exists nowhere else in "reality"; in the lab, we construct worlds of testable principles and then build a useful, comprehensible system of information transfer and creation around those principles. Science "is not 'about nature,' it is a fierce fight to *construct* reality. The *laboratory* is the workplace and the set of productive forces, which makes construction possible" (Latour 1986, 243).

Our laboratories are places of ritual, places where we can apply our observations and our actions to the world in ways that are descriptively and functionally akin to the rituals of religious occupation. What makes them science, as opposed to religion, is not that they are some final epistemological source of truth but rather that they interact within our object-subject continuum according to different observations from, for example, a bear sacrifice. Science asks different questions, utilizes different means, and finds different answers than religious ritual.

We perceive that the laboratory, as a place of knowledge accumulation, plays a role in our worldviews; no one in the industrialized world can truthfully claim that she does not believe in the results of what the laboratory brings us. No one denies that airplanes fly and radios transmit voices and sounds. More to the point, can the scientists of our laboratories accept that they play a reciprocating role within society, one that does not exist as in the "real" world but nevertheless has something to say about that world (whatever it may be)? The ritual of experimentation not only has something to say about the experienced world, it is at its best when it is incorporated as a knowledge-making system. When we, as humans, interpret the interactions of our laboratory system to the world it purports to emulate (but of which, we must admit, it has no knowledge), we truly create and advance knowledge, but this advancement hinges upon the network that permits it. "The subject alone is not the foundation of knowledge, and the transcendental is not in him. Knowledge is nothing without a collective to found it. The collective is nothing without the circulation of the quasi object. This circulation is dissimulated; the quasi object itself is hidden. Knowledge is founded in the collective practices that the collective does not understand" (Serres 1991, 104).

A thorough examination of ritual, in its religious and scientific usage, allows us to see how knowledge is discovered and maintained in a system of information networks. Networks allow us to describe the way that the laboratory interacts with humans. Ritual is not the ignorant stepchild of experimentation. Rather, experimentation, which hinges upon a fiduciary act of knowledge accumulation, ritually seeks to expand human world comprehension through a global system of networks. Ritual directs our attention toward specific incongruities and items of information and enables people to examine the way particular objects interact within a network; but the system must be understood and maintained (not dissolved in the misguided attempt to assert the independence of scientific knowledge) in order to properly understand the object that does not really exist in itself. An understanding of religious ritual and the role of science in cultural networks enables us to see science more clearly and more impressively. The laboratory operates within the constraints of ritual similarly to religion, but this operation is not the weakness of science. Rather, the ritual function of science is its creative genius—it offers us the opportunity to exceed the mere collection of facts and, instead, construct a system of knowledge from the interpretation of those facts.

NOTES

1. Bruno Latour has coined the term *nonmodern* to refer to the fact that what he perceives to be the essential aspects of the modern period, the systemization and establishment of exclusive terms and authority, never existed. Rather, he proposes that the networks supposedly excluded by the modern framework have continued to operate throughout the modern period.
2. Physics has gained an epistemological authority as the basis of modern science. According to reductionist theories, the laws of physics ultimately ground all natural functions, so they rule even in nonphysics labs, such as those of biology.
3. I discuss knowledge making in depth in the section "Ritual Experimentation."
4. Bragg's reference is actually to the relationship of science and religion, but the analogy is commensurate.
5. By "hybrid," Latour means a quasi object, which is neither distinctly natural (i.e., an object for the transcendental subject), nor distinctly cultural (the creation of human thought without regard to the reality of the quasi subject itself). The quasi subject, also called the quasi object, is an object that is simultaneously subject; it both acts and is acted upon, requiring that it be considered a hybrid of nature and culture rather than simply an object of inquiry.

REFERENCES

Barbour, Ian. 1997. *Religion and Science: Historical and Contemporary Issues*. San Francisco: HarperCollins.

Barnes, Barry, David Bloor, and John Henry. 1996. *Scientific Knowledge: A Sociological Analysis*. Chicago: Univ. of Chicago Press.

Bragg, William Henry. 1920. *The World of Sound*. London: G. Bell.

Derrida, Jacques. 1996. "Faith and Knowledge: The Two Sources of 'Religion' at the Limits of Reason Alone." In *Religion: Cultural Memory in the Present*, ed. Jacques Derrida and Gianni Vattimo, 1–78. Stanford, Calif.: Stanford Univ. Press.

Kuhn, Thomas. [1962] 1996. *The Structure of Scientific Revolutions*. Chicago: Univ. of Chicago Press.

Heidegger, Martin. 1977. "The Age of the World Picture." In *The Question Concerning Technology and Other Essays,* 115–53. New York: HarperCollins.

Knorr Cetina, Karin. 1999. *Epistemic Cultures: How the Sciences Make Knowledge*. Cambridge: Harvard Univ. Press.

Latour, Bruno. 1986. *Laboratory Life: The Construction of Scientific Facts*. Princeton, N.J.: Princeton Univ. Press.

———. 1993. *We Have Never Been Modern*. Cambridge: Harvard Univ. Press.

———. 1998. "How to Be Iconophilic in Art, Science, and Religion?" In *Picturing Science, Producing Art*, ed. Peter Galison and Caroline Jones, 418–40. New York: Routledge Univ. Press.
———. 1999. *Pandora's Hope: Essays on the Reality of Science Studies.* Cambridge: Harvard Univ. Press.
Putnam, Hilary. 1987. *The Many Faces of Realism*. La Salle, Ill.: Open Court.
Rappaport, Roy. 1979. *Ecology, Meaning, and Religion*. Berkeley, Calif.: North Atlantic Books.
———. 1992. "Ritual, Time and Eternity." *Zygon: Journal of Religion and Science* 27 (March): 5–30.
Serres, Michel. 1991. *Rome: The Book of Foundations*. Stanford, Calif.: Stanford Univ. Press.
———. 1993. *Angels: A Modern Myth*. Paris: Flamarion.
———. 1997. *The Troubadour of Knowledge*. Ann Arbor: Univ. of Michigan Press.
Serres, Michel, and Bruno Latour. 1995. *Conversations on Science, Culture, and Time*. Ann Arbor: Univ. of Michigan Press.
Shapin, Steven. 1996. *The Scientific Revolution*. Chicago: Univ. of Chicago Press
Smith, Jonathan Z. 1982. *Imagining Religion: From Babylon to Jonestown*. Chicago: Univ. of Chicago Press.
———. 1987. *To Take Place: Toward Theory in Ritual*. Chicago: Univ. of Chicago Press.
Turner, Victor. 1969. *The Ritual Process*. Chicago: Aldine.