AMERICAN INDIAN CULTURE AND RESEARCH JOURNAL 23:4 (1999) 91–114

American Indian Science Education: The Second Step

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Recent years have witnessed an expansion of culturally relevant education programs for American Indian youth. These programs, which are a response to underachievement in scientific and technical fields, focus on curricula and methods that render science more accessible to Indian students. They do so by adapting to the "learning styles," the interactional and social patterns, the common knowledge, and the community needs that may distinguish Indian students from their non-Indian classmates. Many of the resulting programs are impressive, showing monumental dedication and tremendous creativity on the part of their staff. Indian science education has taken a giant step.[1]

Now, however, there is an opportunity to take another step. This article, while applauding the achievements of culturally relevant science programs, suggests that many such programs may carry with them unintended consequences. In order to clarify this assertion, I first examine some assumptions which tend to characterize mainstream science classrooms and some of the contrasting assumptions which may appear in various American Indian traditional thought systems. I discuss some specific examples of culturally relevant science programs, showing that the tendency is to overlook or deemphasize the differences just explored. I then argue that the outcome of such neglect is likely to be that American Indian traditional knowledge is severely damaged, even destroyed. I close by considering what science programs might look like if they pressed innovations in culturally relevant programming toward a second and more dramatic step that more explicitly insists upon the legitimacy of traditional American Indian models of inquiry into the natural world.

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EXPLORING CLASSROOM SCIENCE

When exploring the ways in which science is taught in mainstream classrooms, it is vital to be clear about the intent and focus of such an analysis. I must emphasize that I am speaking of science *teaching* rather than of science *per se.* A variety of philosophers and sociologists of science have suggested that assumptions similar to those I will describe below as characteristic of science teaching often characterize scientific thought quite generally.[2] But some readers may object, arguing that certain aspects of the following portrait of scientific inquiry are overly simplified when compared to the most recent philosophies of science and to the claims of professional scientists themselves about their work.[3]

Fortunately, the purposes of this article do not require that we establish what science truly is or does. They require only that we understand the scientific model of inquiry that is taught in the majority of classrooms. I support my generalizations about the model of inquiry typifying children's science classrooms through the use of illustrative excerpts from a sample of textbooks published within the last ten years and used to train science teachers. These books are readily available across the country.[4] They consistently define the model of inquiry that teachers are likely to present in mainstream classrooms—the model that Indian students will experience before arriving in any culturally relevant program.

Although the following portrait of science may represent a simplified version of what philosophers of science have written, there are heuristic reasons for such simplification, and I do not intend to criticize this model or urge its abandonment in classrooms undertaking culturally relevant science education. My goal here is only to draw out the *differences* between this model of inquiry and other possible models implicit in indigenous philosophies—models that may well be taught to Indian children *in addition to* that of classroom science.

My goals, then, are to put different models of inquiry into direct conversation with each other by illuminating their fundamental assumptions and thinking about ways to enrich that dialogue. The assumptions about scientific inquiry into the natural world, which are commonly presented to teacher trainees in the textbooks they use, relate to the following areas.

Proper Objects of Inquiry

Classroom science, as represented in the textbooks surveyed, recognizes as its proper objects only those things which impinge on the wakeful senses from the physical world. One textbook, for example, notes that science is always based on observation and instructs aspiring teachers: "In guiding children, help them to understand that only data that can be detected by the senses is 'observable evidence.... [T]he senses must confirm that something tangible exists.'" The senses, it is duly noted, are limited to five: seeing, hearing, touching, tasting, smelling.[5] "Facts" and "evidence" are the product of this kind of observation, and textbooks are relentless in their warnings that it is upon these and these alone that judgments about the world are to be made.

Moreover, there is an emphasis on evidence that can be subjected to repeated observations: "Scientists assume that, under the same conditions, natural events are 'reproducible.' That is, they will recur either naturally or ...in the laboratory. Any qualified scientist should be able to observe or produce the event if the necessary conditions are made public." Acceptable claims, in short, are based on strictly sensory observations and on evidence that is "public" and "verifiable" by others.[6]

The Order of the Natural World

The scientific model characterizing teacher training textbooks aims at expressing relations between observed events in terms of general principles or laws: "Science is to a very large extent the search for underlying laws...." These laws describe relationships that are best understood in terms of *causality*. Accordingly, a "good science program...will encourage [students]...to look for the cause and effect of things that are happening to them"; "[t]he notion of cause and effect is the basis of scientific thinking," and "[scientific] evidence must...establish cause-and-effect relations."[7]

Knowledge and Universality

Scientific laws are further characterized, explicitly or implicitly, in terms of universalism. One textbook, for instance, states that a fundamental scientific value is the discovery of "the universality of basic laws." It illustrates this universality through a discussion of Newton's investigation of the law of gravitation and his conclusion that it applied to "every particle in the universe." The author emphasizes that "[y]ou will notice the use of the word 'universe' in this formulation and the clear indication that its importance arises from its universality."[8]

The Nature of the Universe

If not all relationships of interest to science may be stated in universal terms, they are all expected to be impersonal. Accordingly, the individual characteristics of the investigator—sex, gender, race, nationality, personality, or other distinguishing characteristics—do not affect the outcome of inquiries into the workings of the universe. This is true because the universe is, itself, devoid of personal qualities. Beliefs to the contrary may be explicitly referred to as "magical" or "superstitious."[9]

A particular problem that can arise for students, in relation to the assumption of an impersonal universe, is anthropomorphism. A textbook author warns that "[c]hildren commonly read stories or see TV cartoons in which animals talk, the sun smiles....Giving human characteristics to nonhuman objects is called *anthropomorphism.* Children usually have no trouble deciding whether such events are true or fictional. But sometimes they make anthropomorphic inferences without realizing it." Such inferences become evident when children improperly "imbue...animals with human personality traits"; when they "ascribe a conscious purpose to nonhuman things," such as plants or animals; or when they "endow...object[s] with life and human feelings," as when they imagine that rain occurs when clouds cry. Teachers must guard against such unwitting, false conclusions and guide pupils aright. "Anthropomorphism in all its forms can be overcome by pupils when they learn how to make proper inferences from their observations."[10]

Prediction and Control

The presumed centrality of laws or law-like relationships that are impersonal, causal, and (in prototypical cases) universal, leads easily to the expectation of accurate scientific prediction. The regularities of the physical world are so dependable, so independent of their observer, that it is eminently possible to anticipate them. Thus, "scientific inquiry...is primarily directed toward understanding how something works and how to use this understanding to predict phenomena," and "[i]n...science the aim is to...have an *explanation* for what is known from which predictions are made."[11] Indeed, accurate prediction is so important to classroom science that its failure can be disastrous for a theory: "'you can disprove a theory by finding even a single observation that disagrees with the predictions of the theory....[I]f ever a new observation is found to disagree, we have to abandon or modify the theory.'"[12]

Not only prediction, but exploitation or control of nature's regularities is likewise desirable and feasible. The ideal of scientific exploration and achievement is based upon instrumental manipulation of the physical world—its management in such ways that laws must exert themselves, thereby either adding to the scientist's stock of knowledge or accomplishing some practical goal. Basic scientific skills include "identifying...variables...and selecting those to hold constant and those to manipulate," and science teachers are to "help our children understand their environment and the problems of controlling it."[13]

Language

In the law-governed world of classroom science, words and their users stand outside of recognized relationships. The textbooks, without exception, treat language as unimportant to the workings of the natural world and, indeed, as fundamentally unrelated to its nature and functioning. Thus, one author spends almost half a chapter discussing the role of language in scientific inquiry, but in the end he still strictly limits the possible uses of language to six: description, exposition, persuasion, expression, narration, and poetry.[14]

Another author provides a particularly illustrative example of assumptions about the relative power of physical forces, events, realities, and so forth, as compared to the power of language, when he writes that "[t]he physical world around us is the *ultimate* authority by which the validity of scientific theories and principles is to be judged. Whatever logic there seems to be in hypothetical explanations or relationships, they are only useful in so far as they agree with reality."[15] Here it is clear that it is the physical world which decides, as it were, the truth of claims. Language, appearing here in the form of "hypothetical explanations," does not make such decisions; it has no ability to affect physical reality at all. The world simply is as it is, regardless of what anyone *says* about it.

A third textbook considers language of such marginal importance in carrying out scientific inquiries that it counsels teachers to correct children if they exhibit excessive concern with giving names to objects, as they go about their assigned explorations of nature, rather than concentrating on the qualities of those objects: "Children frequently misinterpret the intention of making observations. In the example above [of a science lesson]...the children might feel it was paramount to name the objects rather than to describe their characteristics."[16] In all these examples, language is understood as having no significant relationship to physical reality.

Ethics

Language is not the only phenomenon that receives short shrift from classroom science. The field also refuses all entanglement with the domain of ethics. "The scientist seeks to discover not what should be but rather what *is*."[17] He must not allow his personal values to influence his work. "Objectivity" figures prominently on lists of necessary scientific values and attitudes.[18] One author elaborates that "'[o]bjective' persons use...processes [of scientific inquiry] in an impersonal manner—without allowing their desires and expectations to influence the process or outcome."[19] The best way for a scientist to keep herself honest is to keep the domains of science and ethics strictly separated.

Evaluation of Complexity

Classroom science values the reduction of explanatory complexity. "Scientists do not seek to discover the most complicated laws that can be imagined. Rather, the scientist's goal is to discover the simplest laws that can explain a phenomenon." Similarly, a "theory...must be a simple, unifying idea that postulates nothing unnecessary ('Occam's Razor')."[20]

The Nature and Sources of Knowledge

Finally, classroom science shows a distinct tendency to equate scientific claims with knowledge, and to do so in an unqualified fashion. The "scientifically literate" student "will learn how to learn, how to inquire, how to acquire knowledge"; "[t]he products of that endeavor [science] are human knowledge"; and "[t]he imperatives from science as a discipline are found in...*what* scientists have found out—*knowledge*."[21]

It is not merely that scientific claims constitute *one* source of knowledge among others; a number of teaching texts suggest that scientific inquiry is the *only* source. Thus, one author urges teachers consciously to extirpate from their classrooms all claims about the natural world that have not passed through the process of scientific verification. The teacher may sometimes allow entry to certain such ideas for the sake of stimulating curiosity or discussion, but s/he must take care that they are "introduc[ed]...in such a manner that they are regarded as alternatives worth considering, not as right answers." Claims originating elsewhere than in the process of scientific inquiry are to be "gradually transformed into more useful ones."[22]

Moreover, at times, classroom science does not hesitate to go so far as to assert that the ability to apply scientific methodologies is identical to the ability to think, with rationality, and even with basic intelligence. The "inquiry skills" common to practitioners of science "are basically *thinking skills*," and "[t]he goal of all science education is to develop...citizens who are able to think and act rationally." Assimilating scientific "knowledge, skills, and associated values" should equip children to "react more intelligently...when trying to solve the problems of a rapidly changing society."[23] A further reflection of this scientific model of inquiry's totality is clearly seen in the expansive claim that "[s]cience is a process of inquiry that should govern our behavior *at all times*."[24]

Summary

The conventionally trained science teacher is carefully schooled to impart to her students a model of inquiry—what I have referred to as "classroom science"—in which knowledge is generated only through intersubjectively verifiable, replicable, sensory observations. These observations are ideally capable of expression in laws that are causal, universal, and impersonal and that allow for the prediction and control of the natural world. This natural world is separate from and unaffected by the language used to describe it, and its exploration is separate from the domain of ethics. A central value governing descriptions of this world is the reduction of explanatory complexity. The results of inquiry yield knowledge, while the ability to apply scientific methods frequently equates with rationality, thought, and intelligence.

EXPLORING INDIGENOUS MODELS OF INQUIRY

Having now sketched some important assumptions of classroom science, let us move to an examination of assumptions that may characterize indigenous knowledge claims. Again, a caveat is in order. It is extremely important to emphasize that there is no single indigenous model of inquiry. The hundreds of Indian tribes in the United States comprise hundreds of separate intellectual and cultural traditions. Yet there are often broad assumptions that underlie traditional models of inquiry in use within a number of tribes, in the same way that repeatedly emphasized assumptions underlie different scientific disciplines or different schools of Western thought.[25] I examine some of those recurrent and fundamental assumptions without implying that they apply to all Indian tribes or to all people within any particular tribe. I support my generalizations with references to the writings of Native peoples or, occasionally, the writings of non-Native peoples who have studied traditional models of inquiry. The assumptions of interest relate to the following areas.

Proper Objects of Inquiry

Indigenous models of inquiry tend to define their proper objects in a less limited fashion than do the textbooks defining classroom science. Sensory perceptions of the physical forms of things are usually not the only means to obtaining reliable and significant information about the natural world and its workings. Indeed, it is often the very experiences that exceed detection by the senses—experiences that classroom science dismisses as unverifiable and therefore unreliable—which convey the most important and most certain information for indigenous thinkers. Tewa author Gregory Cajete writes that, traditionally, "Indians perceived multiple realities in Nature—that experienced by our five senses was only one of many possibilities."[26]

Sam Gill presents a good example of the way in which Indian teachings emphasize the centrality of attending to realities beyond the physical in his discussion of Hopi initiation rituals. In these rituals, children see, for the first time, the familiar kachina dancers, the supernatural beings whom they have reverenced their whole lives, appearing *without their masks*; they recognize the dancers, in fact, as the male members of their own families. Yet, as Gill suggests, this shocking experience is not meant to teach initiates that the kachinas are "nothing more than impersonations." Quite the contrary. The radical disenchantment of the experience instead provokes the Hopi child to a quest for religious understanding founded upon the lesson that "things are not simply what they appear to be."[27]

In addition, Indian models of inquiry frequently recognize a variety of unique (unrepeatable) experiences, as well as a range of interactions with the natural world far outside those accepted by models of classroom science, as valid sources of knowledge about reality. Cajete continues that, in traditional contexts, knowledge may "be received directly from animals, plants, and other living and non-living entities."[28]

One of the more important points embedded in the above contrast between indigenous knowledge claims and those of classroom science is a divergence over the idea of subjective events. While classroom science uses this categorization to exclude certain types of events from consideration, indigenous philosophies may refuse the premise that dreams, visions, and similarly labeled "subjective" experiences are necessarily inaccessible to more than one person. For example, the goal of Native American Church ceremonies is expressed by some participants as the achievement of a state in which all present "have the same vision" or become "of one mind."[29] Such experiences are possible because, for many or most Indian traditions, the dualistic division between subject and object postulated by Western philosophies is artificial.

The Order of the Natural World

Another way in which at least some traditional knowledge claims differ from those of classroom science is in their implied understanding of the patterning of the natural world. Youthful science students, it has been noted, are likely to hear that science seeks law-like generalizations and explanations that concentrate upon relationships of cause and effect. By contrast, the knowledge of many Indian peoples suggests that the order of the physical world can be understood rather differently. For them, it may well be that the order of the world manifests itself not in law-like regularities that exist *apart from* the behaviors of humans and other actors, but develops precisely *out of* their coordinated activity. Men, animals, plants, minerals, supernatural beings, the earth—all that is—may be seen as important contributors to the patterns that emerge to characterize the natural world. In Cherokee creation narratives, for example, the animals work together to arrange a suitable home for themselves, fashioning an earth on which to dwell. Humans place the sun in the sky and cause it to make its daily transit, while Selu, Corn Woman, sacrifices herself to provide life-giving nourishment.

Importantly, this co-creative work is never finished. Rather, in Indian sacred teachings, men and women commonly continue to exchange reciprocal spiritual obligations with all creation: to arise early and sing to the dawn, to honor the directions, to share food and possessions, to dig carefully in the earth, to return offerings to the plant and animal nations for what is harvested, and so on. Creation literally occurs anew every day, in every minute, as all beings continue to work together as in the first moments of the world's existence, weaving in unison the magnificent tapestry of the world. As one writer expresses this idea of continuous co-creation in the Navajo tradition:

> "In the beginning God created heaven and earth," describes the Biblical Genesis. For the Navajo, Genesis might read, "In the beginning and in this very moment, the gods and humanity, working together, create the sky and the earth." Creation is perceived as an ongoing, ever-present, living process, and as much in human hands as in the gods.[30]

Natural relationships are neither immutably determined by inflexible laws, nor are they always best described by the causal logic familiar to classroom science. Instead, the concept of causality tends toward a richer, more multidimensional development. As American Indian author Paula Underwood writes,

> The essence of being Indian, I would say, is to understand the Universe as a totality. It is to understand it as totally related, every part to every other part....It is not to think in sequential terms only—or cause-effect-cause-effect—but in terms of a great, complex, interrelated web of things where cause-effect can't be true, can't be an adequate explanation, because there are too many things going on at the same time and everything affects everything else.[31]

While natural relationships are not immutably determined by inflexible laws, or patterned according to strict principles of cause and effect, Indian perspectives of nature do not lack order. While many events may transpire in Indian creation stories that seem impossible to assimilate into a scientific framework, not just anything can happen: "each category of beings has its appointed function in relation to the world of observable happenings."[32] The order of Indian sacred teachings is simply a broader, less restrictive, less determined order than that suggested by the enduring, causal laws of classroom science.

Knowledge and Universality

Within indigenous systems of thought such as I have described, it becomes less obvious that the inquirer's task is to discover principles or explanations that are universal in their application. The ongoing nature of creation implies that, when responsibilities are not met, no inflexible natural laws can be depended upon to make things run, always and everywhere, in the accustomed manner. Indeed, the familiar relationships in the world—the rising of the sun, the renewal of the deer, the seasonal cycles—may actually collapse, the parts of creation refusing to honor their ancient obligations to humans.[33] Whether or not observable patterns in nature endure depends, to a large extent, on how the beings that participate in them behave—a point which will become clearer in the paragraphs that follow.

The Nature of the Universe

The natural world, as presented by Indian models of inquiry, tends to be highly personalized. Anthropologist Irving Hallowell expresses a central assumption of Ojibwe thought, for instance, when he notes that "any concept of *impersonal* 'natural' forces is totally foreign" to it.[34] Lakota scholar Vine Deloria, Jr. likewise speaks of a "great conception shared by a great majority of the tribes. Other living things are not regarded as insensitive species. Rather they are 'people' in the same manner as the various tribes of human being are people....For some tribes the idea extends to plants, rocks, and natural features that Westerners consider inanimate."[35]

Beings in the natural world frequently possess thoughts, feelings, aspirations, and agendas and can interact on the basis of these with humans. This means, first, that the individual qualities of the investigator—his gender, age, ceremonial knowledge and preparation, and a host of other individual qualities may affect the outcomes of his interactions. It means, second, that children who have learned this way of understanding the world from the sacred, traditional stories of their people are likely to have acquired a highly developed tendency for the anthropomorphic thinking that classroom science sees as its mission to root out.

Knowledge and Prediction

Given a highly personalized universe, accurate prediction may be a less central anticipation in Indian models of inquiry than in the typical science classroom. The natural world becomes a sophisticated co-actor with humans, rather than their slave, and the production of unexpected results, especially in a single instance, need not necessarily invalidate a particular understanding of the workings of the world. Exploitation and control of natural patterns are even less developed expectations. Information tends to be found less by manipulating the world, constraining it to reveal necessary regularities, but more by waiting, listening, watching: "Sciences *force* secrets from nature by experimentation and the results of the experiments are thought to be knowledge. The traditional peoples *accepted* secrets from the rest of creation."[36]

Language

Another characteristic that sets many Indian models of inquiry apart from classroom science involves understandings of language. For American Indian peoples, language, far from being merely descriptive, often plays a creative role in relation to physical reality. Words do not merely tell about a reality beyond themselves but literally call it into being. In the words of Pawnee/Otoe Anna Lee Walters, in indigenous cultures, "the spoken word is revered, and to it are attributed certain qualities.... [T]he spoken word is believed to be power which can create or destroy."[37] Thus, for example, traditional Cherokees have understood the need to exercise great care in the ways that they speak about disease, so as not inadvertently to cause it to appear, and they also use language, in the form of the spoken formulas, to treat disease.[38] Furthermore,

> The Cherokee belief in the powerful, concretizing dimension of ritualistic language is equally shared by other Native American groups. Navajo phenomenology, in particular, celebrates the all-encompassing, generative nature of ritualistic words: "Ritual language is not impotent; it is powerful. It commands, compels, organizes, transforms and restores. It disperses evil, reverses disorder, neutralizes pain, overcomes fear, eliminates illness, relieves anxiety, restores, order, health, and well-being."[39]

Whereas, above, a classroom science textbook recommends that science teachers discourage children from becoming overly involved in the naming of objects observed in their classroom, Indian peoples often consider names among the most important and powerful manifestations of language. Native American Indian languages are often understood to contain the real names for things, the names which define them utterly. To speak the name of a thing is thus to articulate its essential nature—to come into significant relationship with the thing itself and to gain influence over it. American Indian sacred formulae often become powerful in part because they contain the real names of the things or people involved.[40]

Ethics

In many Indian models of inquiry, one finds an unwillingness to "separate the search for knowledge from sacred learning or 'religious' training."[41] One is less likely, therefore, to encounter the division of ethics and knowledge, of "is" and "ought," which is so characteristic of classroom science. As Santee Sioux Charles Eastman wrote, for an Indian person of traditional training, "Every act of his life is, in a very real sense, a religious act."[42] Such a person is unlikely to see the value in an objective approach, which self-consciously holds ethical concerns and values in abeyance throughout the process of inquiry. For her, spirituality properly pervades everything, and ethics is not a realm of behavior separable from others. Learning to live in the world as it is becomes an integral part of learning to live in a good way.

Evaluation of Complexity

Rather than following science in the reductionist goal expressed by Occam's Razor, indigenous thought may stress that proper explanation involves a great deal of complexity. The invocation of multiple perspectives is likely to be especially vital. Underwood, for example, articulates what her traditional teachings call The Rule of Six: "The Rule of Six says that 'For every perceivable phenomena devise at least six explanations that indeed explain the phenomena.' There are probably sixty, but if you devise six, this will sensitize you to the complexity of the Universe, the variability of perception."[43]

For many indigenous models of inquiry, it is often not even merely that alternative explanations should be entertained until such time as it becomes possible to fix upon one and to clear away the needless complexity that the others constitute. Rather, it may be assumed that many explanations—even those that appear directly contradictory or mutually exclusive—may be simultaneously true, each revealing one facet of an immensely complicated whole. Thus, for example, an Ojibwe friend, when asked to choose between the evolutionary theory and her tribe's creation story, comments, "'well, I've heard it said that some of us got here one way, and some of us got here another.'"[44] By her way of thinking, the question of human origins is simply too vast a one to suppose that any person or community could ever grasp the entirety. She does not reject scientific ideas, but she can resist the appeal of a single, elegantly simple explanation and live with the ambiguity resulting from an appreciation of complexity.

The Nature and Sources of Knowledge

The foregoing assumptions constitute a theory of the nature of knowledge and its origins which is quite different from that of classroom science. It is a more generous theory which does not suppose that there is only one source of so-called genuine knowledge. It does not imply that those who speak from within another set of assumptions draw their specific conclusions because they lack the ability to think and to do so rationally and keenly. Such an attitude does not, of course, require that one willingly accept any and all claims, as long as they are made with sincerity. It only means that one allows for claims to be evaluated by reference to the context of assumptions and criteria appropriate to them.

Summary

In American Indian models of inquiry into the natural world, knowledge tends to be received from a variety of observations. Information is not necessarily excluded from consideration if it is gained from sources other than the five senses, from an unrepeatable experience, or from events which are not, by scientific definitions, intersubjectively verifiable. Indeed, ideas of subjectivity and objectivity may be, in themselves, quite different from those assumed by non-Indian thinkers. Indian models of inquiry often find other patterns in the natural world than the law-governed and causal ones sought in typical science classrooms: a broader, more complex, more personalized order, which is rooted in responsible interrelationship and co-creative activity. Laws do not grind blindly away, and the prediction, control, and manipulation of the natural world are less pronounced expectations. Language may be seen as a powerful, active force in the ongoing process of creation, and seeking knowledge becomes a sacred activity through which inquirers begin to penetrate the fabulous complexity of the world. Native models of inquiry understand the methods they prescribe as means of generating dependable, accurate knowledge about the natural world, but do not require the conclusion that there are no other sources of knowledge.

CULTURALLY RELEVANT SCIENTIFIC INSTRUCTION: SOME POTENTIAL DANGERS

We have now considered the radical differences between some central epistemological themes of American Indian thought and the scientific thought characteristic of modern classrooms. The point has not been to criticize either model or to argue for the alteration of either, but only to display their points of divergence. Let us now consider the way in which culturally relevant science education programs deal with the contrasting assumptions characterizing the models of inquiry with which they must often deal—explicitly or implicitly—as they attempt to integrate aspects of traditional culture into science classrooms.

To construct a portrait of recent science education programs for Indian children, I examined all issues of the periodical *Winds of Change* between 1986 and 1996. This monthly periodical is published by the American Indian Society for Science and Engineering (AISES), an organization dedicated to "increasing the critical mass of Indian engineers and scientists."[45] It contains many examples of innovative and creative science programs staffed by dedicated and knowledgeable people.

One significant feature of the articles in *Winds of Change*, however, is the lack of attention to the differences just discussed. Instead, programs frequently start from an assumption that there are really *few* significant differences between the assumptions of classroom science and American Indian models of inquiry. For example, one contributor to *Winds of Change* asserts the typical assumption that "The philosophical view of the most up-to-date sciences is not that different from what has been spoken by the elders of the North American tribes."[46] He finds company in a second, who assures readers that the scientific world view is becoming increasingly "consistent with the philosophy of American Indian traditions."[47] A description of a science program for American Indian young people held at the University of California, Irvine, makes a similar implication when it notes that students "were led to the conclusion that...[Chumash Indian potters] were experimental scientists."[48]

Writers sharing the assumption of the basic sameness of Indian traditional and scientific thought tend to subscribe to the optimistic opinion that relatively straightforward solutions—the introduction of elders or special tutors into the science classroom, attention to issues of learning styles, the use of teaching materials featuring examples more familiar to Indian children, some tinkering with placement practices and presentation of material, more encouragement for students to study harder and more efficiently, concentration on environmental or technological issues of direct relevance to reservation communities, and the like—are the central means to achieve increased Indian participation and success in science. They will agree, more or less, to business as usual in the science classroom so long as selected items from traditional teachings or practices are permitted to coexist alongside accepted scientific dogma.

But has any kind of cultural parity been achieved when traditional and scientific knowledge claims simply stand side by side in the classroom? I will suggest that it has not: that, in fact, something quite different—and quite damaging—tends to occur in such circumstances.

The problem is this. The assumptions of the mainstream science classroom are so clearly and frequently repeated to both teachers and students that it becomes part of all our thinking from a young age. Most of us do not even realize, when we think as the science classroom has taught us to think, that we are proceeding according to a particular set of assumptions at all. I recall hearing of a historic jurist's decision that "husband and wife are one person, and that person is the husband." I suggest that a similar process of reasoning tends to occur in culturally relevant science classrooms in the absence of specific precautions. That is, when teachers do not explicitly address the point that traditional thought and classroom science proceed according to different models of inquiry—when they suggest, instead, that scientific and traditional teachings are "really the same"—*the assumptions that will be tacitly accepted will be those of classroom science.* The equation of scientific and Native knowledge amounts to the simple insertion of the latter into a framework of assumptions proper only to the former. These assumptions are often, as we have just seen, quite different from those which originally generated traditional Native claims. In comparison to that standard, Native claims will usually only appear irrational, unenlightened, or foolish—as would any set of claims which is judged by standards foreign to it.

We can, I think, go even farther than this general observation. We can identify the kinds of demands that are likely to be made upon Native knowledge when it is incorporated into science classrooms wherein the differences between models of inquiry remain unexamined. We can also try to draw out the likely consequences. Even where the intention is to offer culturally relevant programming, the demands made upon Native knowledge in classrooms where a scientific model of inquiry is allowed to rule, if only by default, are as follows.

Amputation

The first demand will be for the amputation of specific aspects of Native knowledge from their larger context. The framework of scientific assumptions will require that certain items and sources of information that Indian thinkers have considered vital must be suppressed. No classroom in which that framework prevails will be able, for instance, to welcome information received from ceremony, from the talking animals described in traditional sacred narratives, and so on. Such inputs may be recognized (in the best case) as significant "beliefs" or "values," or (in the worst case) as superstitions and the product of error and ignorance. Either way, traditional knowledge takes second place to the properly "objective data" of the classroom.

Such a classroom may welcome, say, a consideration of the curative properties of a particular plant. It is much less likely, however, to welcome the same kind of discussion about the sacred stories which describe the network of ceremonial or kinship relationships which humans established with this plant in order to learn of its uses. Those kinds of claims may be considered interesting in some social scientific sense, but they do not have to do with knowledge about the natural world; they are never going to be understood as part of the real business of studying nature.

When parts of traditional knowledge that do not fit with scientific assumptions are excluded from the classroom, something vital to traditional knowledge is lost. Young people are cut off from important knowledge possessed by their ancestors. Even more significantly, they will have been cut off from the means by which they might, themselves, gain access to such knowledge.

Misleading Reinterpretation

There is a second demand that a classroom assuming a scientific model of inquiry may make upon traditional knowledge. This demand is not altogether to exclude events and relationships that do not conform to types deemed possible by science. Instead, it is to integrate them into scientific discussions by reinterpreting them. Here, science explains to indigenous thinkers what their traditional claims "really mean." In this outcome, it is not argued that an American Indian individual has actually perceived certain events or relations in the world, but that the individual must grasp that she has understood them in an unsatisfactory manner.

In the case of dreams, for instance, traditionally trained indigenous persons can perceive them to be a reliable and significant message from the unseen world, a portent, a living being, or an experience of a world as real or more real than the waking one.[49] But in a science classroom that does not explicitly address the differences between scientific and Native models of inquiry, a dream may become the random firing of neurons in the brain.

The regnant scientific model of inquiry may, in such cases, allow for reassurances that both traditional Indian people and scientists "are really talking about the same thing," but that they are simply "using different words." Nevertheless, Indian experience is reduced to the explanatory categories of a far different model of inquiry. Indian knowledge is squeezed and deformed to fit into a very different set of assumptions than the one to which it originally belonged. Classroom science remains undisrupted, unchallenged by another way of inquiring into the world, while that other means of inquiry becomes simply a reflection of its principles.

Spiritualization

A third type of demand made on those indigenous knowledge claims that are imported into scientific classrooms is their *spiritualization*. The demand can encompass the entire body of knowledge or simply any bits and pieces that are stubbornly left over after the application of the first two strategies. Spiritualization of claims relegates them to a safe place as far as the classroom sciences are concerned, a place where they cannot get in the way of, or contradict, scientific claims.

In this demand, statements drawn from indigenous knowledge contexts are recognized as meaningful or acceptable by science only on the condition that they surrender any claim to have described events in the physical world accurately. Surrendering to this spiritualization, Indian knowledge claims become instructive metaphysical metaphors without relevance for the "real" world: symbols, archetypes, legends, and the like.

Many Indian people historically have had very different relationships to their teachings than such language suggests. They have understood them to be true as stated, on their own terms, without translation into another vocabulary. Invoking the assumptions and criteria of evaluation proper to their own philosophies, they have recognized them as knowledge—not simply as uncertifiable beliefs. Moreover, they have recognized them as knowledge that directs and enables action in the real world. Many Indian people today continue in these understandings.

Summary

Indigenous knowledge claims that enter an educational setting in which the dominant scientific philosophy of knowledge remains unchallenged, leaving Native claims consequently trimmed down or reworked in the ways described above, are only in the most superficial sense the same as those that existed within the assumptions that generated them. By allowing their knowledge to enter such contexts, Indian people may seem to salvage some scraps of *what* our ancestors believed. However, we do so at the expense of *how* these things were believed.

When traditional knowledge is refashioned in these ways, it is wholly domesticated. It no longer threatens science with the possibility of a reality, and a way of gaining access to it, outside those that science presupposes. And it cannot be expected to support the values and life-ways that scientifically uncontaminated claims once did. The continuity of central cultural teachings has been subtly but effectively destroyed. All that remains is a body of claims that mirrors and reinforces the scientific model of inquiry—a mute testament to the deeply ideological assumption that all thought systems, in all times and places, have been more or less close approximations to the single source of truth that the modern West has finally perfected: science.

SECOND STEP SCIENCE: CONCEPTUAL ISSUES

Now let us briefly consider the implications for developers of culturally relevant science programs for Indian children. What does an acceptance of the separate epistemological bases of Indian and scientific classroom thought imply for the way that we conceive culturally relevant science programs?

An explicit recognition of different ways of knowing will enable Indian educators to forsake a commitment to scientific philosophies that comes at the expense of our own. This inappropriate commitment appears in at least three ways. The first is the common endorsement of the assumption or implication that science "works" in a way that traditional knowledge does not. For example, when an article appearing in *Winds of Change* contrasts indigenous peoples' "human wisdom" and "ways of the heart" with the "knowledge based in material and physical power which has been perfected by the white race,"[50] there is a clear implication about which type of thinking relates to the real world in which things get done and which type relates to the realm of values and spirituality—the realm that classroom science continually presents as nebulous and undependable. The statement that "Traditional knowledge enables us to see our place and our responsibility within the movement of history," while "[f]ormal American education...helps us to understand how things work" carries the similarly unhealthy implication that indigenous knowledge does not explain—at least not "really"—processes in the world outside of human relationships.[51] In reality, a consideration of the astounding technologies created by indigenous peoples of the Americas will convince anyone that our models of inquiry have made us very successful in achieving results in the physical realm as well as in the non-physical.[52]

The temptation to defer to science also manifests itself in a tendency to accept that science constitutes the criterion by which everything else should be judged. For instance, another article in *Winds of Change* assures readers that "stories abound which are told to demonstrate that Indian medicine is as effective—or is more effective—than white medicine."[53] Such statements imply that value exists only in relation to science (here seen in the figure of "white medicine"): that the obvious goal for Indians is to make their intellectual products equal to or better than those of science, to meet standards of evaluation imposed from without rather than within.

Native authors sometimes expend considerable labor to obtain scientific permission to retain traditional teachings. For example, what are we to make of the assertion that one such teaching (the interrelated nature of all things) has been formulated as a theorem and scientifically tested? Physicist John Bell "actually proves this idea mathematically," a contributor to *Winds of Change* writes enthusiastically, "and real experiments have been done successfully verifying its hypothesis under limited conditions."[54] One must ask here: if it is felt that Indian elders already knew the truth of the idea in question, as here asserted, then why such celebration once science professes to know it, too? It is, perhaps, interesting to discover correspondences between different bodies of knowledge claims. But we need not speak as if Indians really *know* only after science—its presumably "real experiments" and mathematical proofs—sanctions Indian knowledge. We need not facilitate a conclusion that the claims of traditional knowledge are tenuous or undemonstrable—unconvincing in their own right—and must therefore be propped up by a more reliable support.

There is one last way in which we, as indigenous educators, sometimes display a commitment to the assumptions of classroom science in a way that unintentionally disprivileges our own traditional knowledge. It occurs when we suggest that Indian models of inquiry constituted proto-sciences, as in this example: "Educational research gives us the hypothesis that Native subsistence hunters utilize an in-depth knowledge of science that they have not formulated into a system of knowledge in the Western fashion. This intrinsic way of knowing can be used as a framework for learning the Western, scientific way of knowing."[55] Such a statement suggests that traditional Indian people strive, by means of a somewhat disorganized set of ideas, for scientific knowledge, but have not yet arrived. Their ideas, however, can be usefully reordered and informed by the more developed ones brought them by Europeans so that they become the basis for proper scientific thinking. Native students will likely conclude from such statements that in all times and places, people recognized the assumptions of classroom science as the only useful way to take hold of the world.

SECOND STEP SCIENCE: PRACTICAL ISSUES

If we avoid certain conceptual pitfalls by an explicit identification of the models of inquiry underlying American Indian and classroom scientific knowledge, our insights will also produce rather different practical outcomes for the design of culturally relevant science education. Recent programs are sophisticated and successful in many ways, but they may become even more so with increased attention to, and inclusion of, the assumptions guiding indigenous models of inquiry.

In this light, let us consider one science program described in *Winds of Change*, examining the features that make it an outstanding example of culturally relevant education, as well as making suggestions for ways in which such programs can speak about the natural world in a voice that clearly acknowledges the validity and authority of knowledge generated within alternative models of inquiry. *Winds of Change* reports on a series of annual programs benefiting Alaska Native students on Saint Lawrence Island. One program is describes in the following way:

> The 1993 class investigated rocks from the island [on which the Indian children live], conducted geochemical sampling for trace metal contamination, investigated radiation again, and built positive thinking skills through various exercises. The class observed the splitting of a walrus hide to be used in making a skin boat.
>
> The elders [who participated in the program] talked about reading ice conditions, weather, the ocean currents and the rules for hunting.[56]

One of the clear benefits of the program is that scientific information has been creatively packaged and presented so that it bears clearly on local issues with which children have familiarity—a fine strategy for generating enthusiasm and interest. Even more significant is the elders' participation, especially since many of them, it is elsewhere noted, conducted discussions with the children in their native language. Since philosophical assumptions are often presupposed in the very structure of languages, this is an advantage that can hardly be overstated: it can be a subtle but effective means of countering the unquestioned supremacy of the scientific model of inquiry that dominates most classrooms.

Supposing, however, that such a program even more self-consciously undertook to assert the validity of an indigenous philosophy of knowledge. What might it do then? Let us suppose, for instance, that the students were invited not only to learn to measure radioactivity in local rocks, but also to encounter their tribe's traditional, sacred knowledge about the rocks. For some tribes, this might entail, for example, coming to understand that rocks are living beings and discussing the ways in which humans can establish direct communication with those beings through such means as singing and dancing.

Suppose, again, that the elders were asked not only to discuss the rules for hunting or to demonstrate the process of splitting hides, but also were asked to address the ways in which that type of information was originally received by their ancestors. This might well involve a discussion of ceremony, visions, and dreams. A discussion of the way in which such information was traditionally recorded might then include exploration of creation stories or of artistic expression conceived as a ceremonial process occurring at the intersection point of the seen and unseen worlds.

Throughout such discussion, care would be taken *not* to gloss over or reinterpret traditional teachings that do not easily fit with scientific ones or imply that the ancestors pursued knowledge in the empirico-experimental ways that modern scientists do—but rather through invoking a separate, equally authoritative model of inquiry. Children thus would not be asked to submit traditional teachings to scientific criteria of evaluation in order to determine if they were valid, as happens in too many classrooms; they would learn that there exist other models of inquiry within which claims make sense, and within which their truth can be adjudicated.

Most importantly, suppose that children learned, themselves, to practice traditional ways of seeking, receiving, recording, sharing, and celebrating knowledge as integral aspects of the process of developing a more complete understanding of the world. Learning would then include direct interaction with the drum, ceremony, sacred songs, dances, prayers, dreams, creation stories—all as sources and expressions of knowledge possessed by Indian peoples. These aspects of the program would take on central importance, rather than becoming what they can otherwise become—cultural options tacked onto a fundamentally unmodified scientific curriculum.

Such substantive changes in the methods of science instruction for Indian children are rooted in a clear understanding of science as one model of inquiry among others. The changes recognize both scientific and Indian models of inquiry as valid and authoritative, but they do not try to reduce the claims of one to the claims of the other. Under the structure of most science classrooms, the assumptions of science about what is real and known are simply imposed upon indigenous knowledge. The science classroom that I envision would, instead, celebrate American Indian children's right to understand and participate in their own characteristic ways of knowing, as well as to participate in that of the larger, science-dominated society.

In conclusion, let us speculate about what a second step in culturally relevant science education might look like. The features of such a program might include the following:

- It would refuse to allow the assumptions of classroom science to dominate. Instead, it would *explicitly discuss* the assumptions of that model and of the differing assumptions that have governed traditional models of inquiry in the children's tribe. In these ways, it would resist the amputation, reinterpretation, or entire spiritualization of Native knowledge claims.

- It would not suggest that Western science "works" in the physical world, whereas traditional knowledge concerns itself only with the social or spiritual worlds.

- It would not imply that science can and must validate traditional knowledge, but would stress the importance of evaluating knowledge claims according to the assumptions and standards appropriate to them.

- It would not present traditional thought as a proto-science, an incomplete striving toward a superior revelation realized in Western science. It would not accept the premise, which children exposed to classroom science may already carry with them, that scientific thinking is equivalent to rational thought or to intelligence. Instead, second-step science programs will let children know that traditional knowledge has not been, and should not be, replaced by scientific knowledge, but can coexist with it.

- It would, where possible, give children explicit exposure to an indigenous model of inquiry by allowing them to participate in or to share their experiences with elements like song, dance, dreaming, storytelling, prayer, oral tradition, and so on, as the community and elders deem appropriate.

Revising science education programs for Indian young people along the lines I have suggested will be a difficult task. But even communities that find themselves unable to institute the last suggestion above could institute the first four. Those changes alone would be a great accomplishment. They would help children free themselves from learning that, in the words of one of the science textbooks quoted earlier, science must "govern our behavior *at all times*."[57] They would allow children to embrace their scientific training without rejecting their elders as people who, by their unscientific beliefs, show themselves (unfortunately) as mired in anthropomorphism, incapable of rational thought, and lacking in intelligence. It would allow our children to become scientists without leaving behind their Indianness.

CONCLUSION

Science education for Indian children has made an impressive first step by creating exciting and innovative programs that have generated a great deal of enthusiastic participation on the part of students. They create science programs for Indian children that often make room for traditional claims beside scientific ones. However, developers of future programs may wish to consider taking a second step.

This step involves a recognition that classroom science and the teachings of Indian tribes draw on models of inquiry which differ in specific ways. It realizes that simply to insert traditional knowledge into a context dominated by foreign assumptions is tacitly to accept and reinforce a model of inquiry that will rework or reinterpret traditional knowledge. It understands that traditional knowledge emerges from such encounters superficially similar, but really profoundly compromised: that such knowledge will not support the distinctive Indian culture that it once did because it has become simply a mirror of science.

Implementing educational programs such as I have described will, of course, be difficult. It may be difficult to find the right mix of teachers for such programs, and even more difficult to arrive at consensus in communities about what parts of traditional knowledge should be addressed, how such issues should be taught, and who should teach these topics. Because tribes have diverse traditions that encode knowledge differently, each tribe will have to work out programs that are right for their specific traditions.

Yet Indian science education has reached the stage where a second step is possible and urgently necessary for the preservation and renewal of traditional knowledge. It has become possible for Indian people to refuse to speak about ourselves in ways foreign to us, to explain ourselves in terms not appropriate to us, to judge ourselves by criteria we did not institute, or to accept that our traditional knowledge is not knowledge at all. We can hold firm our own indigenous ways of knowing and, in so doing, protect and preserve those ways. Are Indian people and other educators ready to seize the opportunity for a second step in reclaiming the scientific education of our children? Are we ready to fight for a place for traditional ways of knowing in science classrooms?

NOTES

1. See Jeff Burton, "Both Ways of Knowing," *Winds of Change* 8:4 (1993): 166–71; Candy Hamilton, "Forget Textbooks and Memorizing," *Winds of Change* 7:4 (1992): 74–79; Muriel Shishkoff, "A Program Worth Repeating," *Winds of Change* 8:1 (1994): 24–27; Pete Murphy, "Educational Revolution on the Reservation," *Winds of Change* 8:1 (1993): 12–19.

2. See Richard Rorty, *Philosophy and the Mirror of Nature* (Blackwell: Oxford, 1990); Michael Mulkay, *Science and the Sociology of Knowledge* (London: Allen and Unwin, 1979); or Evelyn Fox Keller, *Reflections on Gender and Science* (New Haven: Yale, 1995).

3. Readers interested in pursuing this argument may wish to examine Ilya Prigogone and Isabelle Stengers, *Order Out of Chaos: Man's New Dialogue with Nature* (Boulder: New Science Library, 1984). These authors—one a Nobel laureate in chemistry and one a philosopher of science—argue for a "reconceptualization of physics" (p. xxx), taking up many of the same ideas I will discuss below. Constraints of space prevent adequate discussion of their argument here, but it suffices to say that they call into question many of the scientific assumptions noticed below. They pay a great deal

of attention to the regnant assumption that scientific laws are universal and eternal. They also question the assumption that nature is "dead and passive" (p. 6) and investigate fresh understandings of complexity in nature. They reevaluate the value of scientific objectivity and suggest serious revisions in the conceptualization of causality.

4. I examined a total of thirty textbooks, which I randomly sampled from a list of all books listed under the subject heading of "Science—Study and Teaching" in the online databases provided by Online Computer Library Center, Inc. (OCLC) and Research Libraries Information Network (RLIN). For the purposes of the article, I then extracted exemplary quotations and citations.

5. Peter Gega, *Science in Elementary Education,* Seventh Edition (Upper Saddle River, NJ: Prentice Hall, 1994), 9, 72. See also Wynne Harlen, *Teaching and Learning Primary Science,* Second Edition (London: Paul Chapman Publishing, 1993); Marvin A. Tolman and Garry R. Hardy, *Discovering Elementary Science: Method, Content, and Problem-Solving Activities* (Boston: Allyn and Bacon, 1995), 40; William R. Zeitler and James P. Barufaldi, *Elementary School Science: A Perspective for Teachers* (New York: Longman, 1988), 94.

6. Gega, *Science in Elementary Education,* 9, 13; similarly, Richard Duschl, *Restructuring Science Education: The Importance of Theories and Their Development* (New York: Teachers College Press, 1990), 77.

7. Edward Victor, *Science for the Elementary School,* Sixth Edition (New York: Macmillan, 1989), 9; David Womack, *Developing Mathematical and Scientific Thinking in Young Children* (London: Cassell Education, 1988), 21; Gega, *Science in Elementary Education,* 13. See also George DeBoer, *A History of Ideas in Science Education: Implications for Practice* (New York: Teachers College Press, 1991), 15.

8. Subramanyan Chandrasekhar, *Truth and Beauty: Aesthetics and Motivations in Science* (Chicago: The University of Chicago Press, 1987), 4–5.

9. Victor, *Science for the Elementary School,* 19.

10. Gega, *Science in Elementary Education,* 87, 11–12.

11. Robert J. Marzano, *A Different Kind of Classroom: Teaching with Dimensions of Learning* (Alexandria, VA: Association for Supervision and Curriculum Development, 1992), 52; Harlen, *Teaching and Learning,* 9; see also Gega, 71.

12. Harlen, *Teaching and Learning,* 11, quoting Steven Hawking, *A Brief History of Time* (London: Bantam Press, 1988), 10.

13. Tolman and Hardy, *Discovering Elementary Science,* Dix40; Victor, *Science for the Elementary School,* 10. Similarly, Joseph Abruscato, *Teaching Children Science,* Fourth Edition (Boston: Allyn and Bacon, 1995), 4; Duschl, 50; Harlen, *Teaching and Learning,* 8.

14. Abruscato, *Teaching Children Science,* 110–11.

15. Harlen, *Teaching and Learning,* 8.

16. Zeitler and Barufaldi 1988, *Elementary School Science,* 95.

17. Abruscato, *Teaching Children Science,* 9.

18. See, for instance, Zeitler and Barufaldi, *Elementary School Science,* 107.

19. Ibid., 9; Gega, *Science in Elementary Education,* 11.

20. Abruscato, *Teaching Children Science,* 8; Duschl, 78.

21. Edward Victor and Richard D. Kellough, *Science for the Elementary and Middle School* (Upper Saddle River, NJ: Merrill, 1997), 9; Ibid., 22; Gega 1994, 5.

22. Harlen, *Teaching and Learning,* 35, 30.

23. Victor, *Science for the Elementary and Middle School,* 9, 11, 16 (emphasis added).

24. Zeitler and Barufaldi, *Elementary School Science*, 8.
25. Laurie Anne Whitt writes,

> given the existence of some five thousand distinct indigenous nations worldwide, reference to an "indigenous" knowledge system...is empirically tenuous at best. Nevertheless, as [Jose] Barreiro notes: "Native peoples of the Americas exhibit both cultural diversity and philosophical consistency...the...principles that guide the Native cultures bear a remarkable resemblance to one another." Concrete diversity does not preclude commonality or community...(Laurie Anne Whitt, "Indigenous Peoples and the Cultural Politics of Knowledge," in *Issues in Native American Cultural Identity*, ed. Michael K. Green [New York: Peter Lang, 1995], 225).

26. Gregory Cajete, *Look to the Mountain: An Ecology of Indigenous Education* (Durango: Kivaki, 1994), 75.
27. Sam D. Gill, "Hopi Kachina Cult Initiation: The Shocking Beginning to the Hopis Religious Life," *Journal of the American Academy of Religion* 47: Supplement A (1996): 92.
28. Ibid., 75.
29. The sources of these quotes are personal conversations, during the spring of 1992, with present and former members of the Native American Church.
30. David Jongeward, *Weaver of Worlds* (Rochester, VT: Destiny Books, 1990), 40. Various parts of Jongeward's book—a biographical description of his wife's exploration of Navajo weaving—fail, by his own admission, to grasp central aspects of Navajo teachings. This particular quote seems to me, however, to capture an important idea quite elegantly—especially if one adds the involvement not only of men and gods, but of all life forms.
31. Paula Underwood, *Three Strands in the Braid: A Guide for Enablers of Learning* (San Anselmo, CA: A Tribe of Two Press, 1991), 29.
32. Robin Horton, "African Traditional Thought and Western Science," in *Rationality*, ed. Brian R. Wilson (Basil Blackwell: Oxford, 1986), 133–34. Horton makes this latter point about indigenous African knowledge systems, but it is equally applicable here. For instance, James Mooney writes that in Cherokee theories of and formulas for treating disease, the various spirits involved "always appear and behave according to most rigidly circumscribed patterns" (p. 42). James Mooney and Frans Olbrechts, *The Swimmer Manuscript: Cherokee Sacred Formulas and Medicinal Prescriptions*, Smithsonian Institution Bureau of American Ethnology Bulletin 99 (Washington, DC: Government Printing Office, 1932).
33. For instance, among Native tribes, "[t]here was a widespread belief that each animal had a spirit village to which they returned and reported their treatment by humans. This report directly affected whether that species of animal would give its life for humans in the future" (Cajete, *Look to the Mountain*, 98).
34. A. Irving Hallowell, "Ojibwa Ontology, Behavior, and World View," in *Primitive Views of the World*, ed. S. Diamond (New York: Columbia University Press, 1960), 59.
35. Vine Deloria, Jr., *God Is Red: A Native View of Religion* (Golden, CO: Fulcrum, 1994), 89–90.
36. Vine Deloria, Jr., "Traditional Technology," *Winds of Change* 5:2 (1990): 16–17.
37. Anna Lee Walters, *Talking Indian* (Ithaca: Firebrand, 1992), 11. See also N.

Scott Momaday, *The Way to Rainy Mountain* (Albuquerque: University of New Mexico Press, 1969), 33. The retention of this concept of language as creative and powerful sometimes forms the basis of the objection of contemporary Indian persons to the exploitation of traditional ceremonies (such as the sweat lodge) by minimally knowledgeable practitioners: the latter may be perceived as unintentionally creating, through ritual discourse, relations they will be unable to direct or arrest.

38. Lee Irwin, "Cherokee Healing: Myths, Dreams, and Medicine," *American Indian Quarterly* 16:2 (Spring 1992): 243.

39. Alan Kilpatrick, *The Night Has a Naked Soul: Witchcraft and Sorcery among the Western Cherokee* (Syracuse: Syracuse University Press, 1997), 27, quoting Gary Witherspoon, *Language and Art in the Navajo Universe* (Chicago: University of Chicago Press, 1977), 34.

40. See also discussions throughout Jack Frederick Kilpatrick and Anna Gritts Kilpatrick, *Walk in Your Soul: Love Incantations of the Oklahoma Cherokees* (Dallas: Southern Methodist University Press, 1965); and Jack Frederick Kilpatrick and Anna Gritts Kilpatrick, *Run Toward the Nightland: Magic of the Oklahoma Cherokees* (Dallas: Southern Methodist University Press, 1967).

41. Peggy Beck, Anna Lee Walters, and Nia Francisco, *The Sacred: Ways of Knowing, Sources of Life* (Tsaile, AZ: Navajo Community College Press, 1992), 48.

42. Charles Eastman, *The Soul of the Indian* (Champaign, IL: Project Gutenberg, 1995), 47.

43. Underwood, *Three Strands,* 13.

44. My appreciation to Delores Brunelle for providing this example.

45. F. Hickman, "Report of the 1985 AISES National Convention," *Winds of Change* 1:3 (1986): 38. *Winds of Change* provides a particularly instructive example for the purposes of this article. First, it is known and respected by many Indian people, and therefore may be expected to be significantly influential within the Indian community. Second, my own experience suggests that the assumptions evident in *Winds of Change* characterize a much larger body of discourse and practice.

46. Richard Simonelli, "The Longest Road: Phil Lane, Jr. Addresses Student Pugwash Conference on Science and Ethics," *Winds of Change* 4:3 (Autumn 1989): 18.

47. Cecilia Jacobs, "Teaching Science-based Alcohol Curriculum for American Indians (T-SACAI)," *Winds of Change* 4:4 (1989): 106.

48. Shishkoff, "A Program Worth Repeating," 26.

49. For instance, John Moore suggests the importance of dreams to one tribe when he writes that "in their narratives of religious experience, Cheyennes do not differentiate between what white people would call reality, and the dreams and other visions stimulated by prayer, smoking, fasting, loss of sleep and drugs such as peyote. While a white person might want to know whether a buffalo or wolf really visited a supplicant on Bear Butte, a Cheyenne religionist is indifferent to this question, which he considers irrelevant to the religious quest, and perhaps a rude attempt to discredit native religion" (John Moore, *Studying the Native American,* ed. in Russell Thornton, forthcoming). A discussion of dreams among Plains Indian peoples appears in Lee Irwin, "Dreams, Theory, and Culture," *American Indian Quarterly* 18:2 (Spring 1994): 229–46. Charles Hudson provides a brief but interesting discussion of southeastern Indian dreaming in *The Southeastern Indians* (Knoxville: University of Tennessee Press, 1976), 344.

50. Simonelli, "The Longest Road," 20, 16.

51. Vine Deloria, Jr., "Knowing and Understanding," *Winds of Change* 5:1 (Winter 1990): 18.

52. See, for instance, J. McGiver Weatherford, *Indian Givers: How the Indians of the Americas Transformed the World* (New York: Fawcett Columbine, 1988); or J. McGiver Weatherford, *Native Roots: How Indians Enriched America* (New York: Fawcett Columbia, 1992).

53. M. N. Taylor, "Modern American Indian Medicine," *Winds of Change* 1:3 (1986): 36.

54. Simonelli, "The Longest Road,"20.

55. Burton, "Both Ways of Knowing," 167.

56. Ibid, 170.

57. Zeitler and Barufaldi, *Elementary School Science,* 8.