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# Deepening the Debate over 'Sustainable Science': Indigenous Perspectives as a Guide on the Journey

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ABSTRACT
This article engages with the concept of *sustainable science* as articulated by those eager to address and correct environmentally destructive tendencies in western scientific theory and practice. We first reflect on the widespread resistance among western scientists to accord the designation of 'science' to other cultural enterprises of inquiry. Focusing on the example of Native American approaches to nature and knowledge, we caution that this pervasive sense of superiority has blocked recognition of reasonable paths to a new science even amongst those eager to incorporate elements of Indigenous thinking into their worldviews. Finally, we argue that the explorations of the natural world as found in Indigenous science can be seen to represent an alternative mode of rigorous, systematic inquiry – a 'full-spectrum' approach – demonstrating the practical potential for truly sustainable science. Copyright © 2009 John Wiley & Sons, Ltd and ERP Environment.

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## Introduction: Sustainable Science – a Useful Heuristic Device

MORE THAN A DOZEN YEARS HAVE PASSED SINCE THE ENVIRONMENTAL EDITOR OF THE MAGAZINE *WINDS OF Change* extended an invitation to his readers to participate in a discussion about 'sustainable science'. Richard Simonelli set out his belief that indigenous approaches to understanding and co-existing with the natural world constitute a 'full-spectrum science', drawing 'freely on all four of the gifts that have been given to us as human beings: the spiritual, emotional, mental and physical'. Western science, Simonelli argued (1994, p. 37), must change in order to address the destructive consequences flowing from its rejection of the spiritual and emotional dimensions of both natural reality and human inquiry. Arguing that cutting-edge western science is beginning to see the light, he offers the concept of *sustainable science* as a 'roadway to environmental justice':

> Sustainability refers to ways of being that have a future, ones that don't burn their bridges behind them or have hidden 'scorched earth policies' as part of their way of doing things. Sustainable activities are ones that continue to nurture individuals, families, communities and the environment as they unfold. They are world-views or ways of living that create health rather than sickness as they go along. Recently people have spoken of sustainable agriculture, sustainable economic development, sustainable energy usage, sustainable forestry,

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> and even sustainable family life.... [We] will begin to speak of 'sustainable science', and wonder out loud and in print what changes in the viewpoint and activities of science and technology must happen in order for them to be sustainable – in other words, to lead to a survivable future (Simonelli 1994, p. 36).

A second article in the same issue of *Winds of Change* furthered the discussion by pointing to the limits of reductionist and analytical approaches to scientific inquiry. The authors, Helmut Hirsch and Helen Ghiradella (1994, pp. 38–42) – both professors of biology – recount their own efforts to create a setting for their students in which 'western stories about the living world and those of American Indians could co-exist'. Hirsch and Ghiradella are in the fortunate position of working at the State University of New York at Albany, which, at the time of their writing, had recently received funds from the Howard Hughes Foundation to establish a residential community for students interested in the sciences. Inspired by the holistic approach taken by their American Indian friends toward the natural world, they renamed their residence the 'science longhouse', thus signaling their intent to reintroduce 'values and reverence into the western educational setting' (Hirsch and Ghiradella, 1994, p. 41).

For Hirsch and Ghiradella, this effort to radically alter science education stems from concerns about what they perceive to be a dangerous and entrenched privileging of the pursuit of high technology and 'the great rush toward size and power' over a simpler science springing from a 'sense of curiosity and wonder' and infused with humane and ecologically responsible values. Hirsch and Ghiradella have no illusions about the difficulty of such a venture, and further acknowledge the likely problems students choosing such a path will face in a 'job market' (academic and otherwise) operating with an antithetical worldview.

A few years after the idea was floated by Simonelli, Hirsch and Ghiradella, the concept of sustainable science was picked up by feminist science scholar Londa Schiebinger. Schiebinger (1997, p. 202) was interested in advancing the debate within feminist science theory, arguing that, although feminist science theorists 'ably uncover' problems, they 'rarely suggest concrete solutions or programs' designed to overcome them. 'Sustainable science' – a phrase she credits Hirsch and Ghiradella with coining – is particularly useful, she argues, in broadening the existing notion of socially responsible science to 'include responsibility toward nature as well as culture'. Such an emphasis, in turn, 'shifts attention away from classical epistemology (how we know)' – which, she argues, 'has exercised science and science theory since the seventeenth century' – towards a more practical and humane 'focus on the goals and outcomes of science and who is excluded' (Schiebinger, 1997, p. 212). Urging sustained concentration on the social and environmental realities resulting from scientific investigation, Schiebinger articulates a series of 'key questions' for debate: 'Science for whom? How is our knowledge influenced by who is included in science and who is excluded, which projects are pursued and which ignored, whose experiences are validated and whose are not, and who stands to gain in terms of wealth or well-being and who does not? And for how long?' (Schiebinger, 1997, p. 212).

Building on Schiebinger's contribution, which failed to provoke the desired response, we would like to posit an additional question: is the current unsustainable course of mainstream western science likely to be corrected either with the addition of 'values and reverence', as Hirsch and Ghiradella argue, or by prioritizing progressive outcomes and goals, as Schiebinger suggests? Why do successive generations of well intentioned, thoughtful and progressive critics of the perceived misapplication of scientific energies and research dollars continue to fail in their quest to promote socially progressive and environmentally respectful scientific projects? Is it simply due to the overwhelming power of those who seek to maintain the status quo and continue directing science (and scientists) toward such nefarious ends as the development of weapons of mass destruction, genetically modified plants and animals, non-holistic and potentially dangerous 'high-tech' medicines and the meaningless 'improvement' of trivial and ecologically unsound 'computer age' gadgets? Or is there something more fundamentally amiss with the claims made on behalf of western science and the promises of liberation from the hardships of life that have been the rallying cry of its defenders for centuries? Could it be that a deeper level of critique is necessary, one that traces the violence, waste and profligacy of modern science to the very worldview its praxis embodies and reflects? And could it even be that there already exist forms of sustainable science overlooked precisely because they do not conform to the dictates and presuppositions – set and shared by supposedly 'enlightened' western culture – of what science is and should look and *be* like?

We believe that attempts to modify western science by adding values or worthy objectives while retaining faith in its core investigative principles – its valorization as a uniquely reliable form of knowledge acquisition – will fail

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to produce the desired transformation. We shall reflect on the widespread resistance among western scientists to accord the designation of 'science' to any other cultural enterprises of inquiry and shall demonstrate the way that this pervasive sense of superiority has blocked any recognition of reasonable paths to a new science even amongst those eager to incorporate certain elements of indigenous thinking into their own worldview. Finally, returning to Simonelli's description of Indigenous science as 'full spectrum', we shall argue that its explorations of the natural world both represent an alternative mode of rigorous, systematic inquiry and demonstrate the practical potential for truly sustainable science.

## 'Something Murderous': Sustaining a Deep Critique of Western Science

A common theme running through the arguments made by critics of modern western science is that the priorities of both society and science need to be reconsidered so that scientific investigation is undertaken for the betterment of humankind. Such a vision of the renewal of western science holds, as a central premise, that the funding of and therefore the projects central to scientific investigation have become too closely linked to specific and narrow economic and/or political interests, a myopia predictably generating unsustainable and often dangerous practices. The way forward for these critics is then clear: challenge the relationship between money and science and concentrate on articulating progressive goals for scientific research.

Schiebinger's desire to focus on the goals and outcomes of western science is illustrative of this line of argument. Such a discussion succeeds in focusing our attention on the social, political and economic forces that guide this supposedly neutral activity and thereby successfully demystifies the claims that western scientific investigation is an apolitical activity exploring and expressing (in ever changing approximations) objective truth about natural reality. Other feminist critics of science echo Schiebinger's critique. Deboleena Roy (2004, p. 276), for example, posits that what sets feminist science apart is not a rejection of western scientific method but, rather, its request that scientists 'uncover the social and political forces driving their research questions as well as to establish a relationship with their subject(s)'. In this view one can continue to 'do science' in the western scientific manner but transform it through an articulation of a more sustainable and socially useful agenda. By uncovering the social, political and economic interests driving scientific research we can insist that science be turned in directions beneficial to society as a whole, and especially to those who are weak and oppressed, in place of special interests.

Is this, however, enough? For Schiebinger, as we have seen, the concept of sustainable science is useful particularly because it 'shifts attention away from . . . epistemology' and 'goals and outcomes', with an associated focus on 'who is excluded' (Schiebinger, 1997, p. 212). But what if it is precisely this lack of challenge to the epistemology that has hampered successive efforts to investigate the failure of science to live up to its promise of providing a better future for all? Surely a quest for a sustainable science should not shun these issues but, rather, recognize that it is precisely the form and foundations of western science that provide the circumstances and conditions that lead to *un*sustainable attitudes and practices.

Of course, this fundamental critique of the methods and epistemology of science is not new. Many people from a wide variety of backgrounds have challenged the deeply held beliefs of the defenders of western science. It is a testament to the power of the modern western scientific worldview that its widespread acceptance remains relatively untouched. As the German physicist and philosopher of science Carl-Friedrich von Weiszäcker argued, western science 'started out by destroying the myth of the Middle Ages. And now science is forced by its own consistency to realize that it has merely raised another myth instead' (von Weizsäcker, 1951, p. 71). Rather, *should be* forced: for the myth – science as objective, neutral and uniquely effective in its ability to produce reliable knowledge of the natural world – remains largely intact. The fantasy rests largely on the supposed ability of the reductionist/dissective method to break natural wholes into researchable 'bits' or 'parts' and thus penetrate, practically and analytically, to the 'heart' of the matter under investigation. Because the natural world is conceived materialistically, the scientist is said to be investigating the world *outside of him/herself*. In this reading the individual scientist is in pursuit of *pure* knowledge, unblinkered by any cultural norms or presuppositions. Celebrants of *the* scientific method proudly proclaim its freedom from metaphysical claim. Yet, ironically, the whole enterprise rests on a metaphysical assumption – i.e. a premise neither deducible from nor reducible to physical phenomena – of *the nature of nature* as unenchanted, purposeless and (in either classical or quantum mode) mechanical.

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As physicist Vandana Shiva (1987, p. 244) succinctly notes, 'while serving and promoting a particular set of values, modern science posits itself as independent of values'. Those who have articulated the usefulness of the concept of *sustainable science* are suggesting that the way to reform the status quo is to simply re-think our previous belief in the supposed neutrality of the scientific projects themselves. If we can ensure that the outcomes are to the greater benefit, we will all be better off. However, this was always the promise; science would, by its basic commitment to acquiring deep understanding of the operative basis of life and matter, necessarily lead to a better world. Francis Bacon promised it, now critics of Baconian science promise it: freedom lies in not a revised method but the method's dedication to emancipatory goals. Thus western science continues to be celebrated as the logical source of solutions to the problems that its own method generates. Yet to challenge this foundation, as von Weiszäcker observes, is to incur the indignation of almost all scientists, across the progressive–conservative spectrum:

> It is inherent in the methodological principles of science that certain fundamental questions are not posed. Physics, as it is practiced in modern times, characteristically does not really ask what matter is, biology does not ask what life is, and psychology does not ask what the soul is; instead, these terms just vaguely circumscribe the area one intends to investigate. This fact is probably methodologically fundamental to the success of science. Were we to pose these most difficult questions while at the same time practicing science, we would lose the time and energy needed to solve the solvable questions. As a result, science, which leaves the fundamental questions aside, has progressed incredibly fast in comparison with the very slow, highly dubious process of philosophical reflection, which truly confronts these difficult questions. On the other hand, we must not deceive ourselves: the methodological procedure of science just characterized has something murderous in it if it no longer knows how questionable it is. Those questions are difficult, but they are not unimportant. Heidegger's formula 'Science does not think' can hardly be quoted to any scientist without provoking anger. In Heidegger's sense of the word 'think,' however, the formula is literally correct. For Heidegger takes 'to think' as meaning 'to put oneself in question once more,' and precisely this science will not do in its normal practice. But it must be done if science should someday be able to relate to the living human being, who is a partner in life and not merely an object (von Weizsäcker, 1980, p. 233).

Vandana Shiva has long argued that western science is inherently violent – even, as she says, in its 'peaceful domains' such as health care, agriculture and other areas whose goal is human welfare. Shiva's critique should give pause to those seeking sustainability through a simple change of program. For Shiva, '…modern science is quintessentially reductionist. Its reductionist nature undergirds an economic structure based on private enterprise, both personal and corporate, aimed at capital accumulation and profit maximization regardless of the exploitation and alienation of workers. Reductionist science is also at the root of the growing ecological crisis, because it entails a transformation of nature such that the processes and regularities and the regenerative capacity of nature are destroyed' (Shiva, 1987, p. 243). In contrast to Hirsch and Ghiradella, who believe that 'contemporary science has taken on many of the trappings of a capitalistic enterprise', Shiva posits that there has *always* been a mutually reinforcing relationship between modern western science, capitalism and the historically broader and deeper totalizing impulse of the western imperial enterprise: 'The reductionist world view, the industrial revolution and the capitalist economy were the philosophical, technological and economic components of the same process' (Shiva, 1987, p. 247).

## Method or Culture? False Distinctions Between Knowledge and Science

Exploring the persistent myth of science as 'just a method' – an objective, value-free way to pose and solve problems – Native American psychologist Keith James (2001, pp. 45–46) (Onondaga/Minsi Lenape) writes 'Culture has been defined in many ways. I define it here as an organized set of tools and techniques for understanding, predicting, and (at least partially) controlling circumstances and events. And what is science? It is an organized set of tools and techniques for understanding, predicting, and (at least partially) controlling circumstances and

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events'. Does this mean, though, that science resembles culture, or that it *is* a cultural phenomenon? For James, the answer is clear: culture is 'the spirit beneath the surface' of science, its formative principle and guiding force (James, 2001, pp. 45–49). Praxis tracks and mirrors zeitgeist; science mirrors soul.

If James is right, then the elevation of science *over* culture – its self-enshrinement as the apolitical pursuit of timeless truth – may, ironically, fit a particular cultural logic, express a specific 'spiritual' disposition. Just as the cultural generation of distinct religions is anathema to the monotheistic, missionary spirit, so culturally generated scientific diversity is anathema to the monopolistic spirit of those, like E. O. Wilson (1998, p. 48) here, blessed to have seen *the* light:

> By any reasonable measure of achievement, the faith of the Enlightenment thinkers in science was justified. Today the greatest divide within humanity is not between races, or religions, or even, as widely believed, between the literate and illiterate. It is the chasm that separates scientific from prescientific cultures. Without the instruments and accumulated knowledge of the natural sciences – physics, chemistry, and biology – humans are trapped in a cognitive prison. They are like intelligent fish trapped in a deep, shadowed pool. Wondering and restless, longing to reach out, they think about the world outside. They invent ingenious speculations and myths about the origin of the confining waters, of the sun and the sky and the stars above, and the meaning of their own existence. But they are wrong, always wrong…

Is not such self-righteousness, or exclusionary zeal, characteristic of all deeply held belief systems? The Lakota Sioux scholar Vine Deloria, Jr. (1994, pp. 85–86) quotes an account by the Sioux physician Charles Eastman of a missionary who 'undertook to instruct a group of Indians in the truths of his holy religion. He told them of the creation of the earth in six days, and of the fall of our first parents by eating an apple'. 'The courteous savages', Deloria continues,

> listened intently, and, after thanking him, one related in his turn a very ancient tradition concerning the origin of maize. But the missionary plainly showed his disgust and disbelief, indignantly saying: 'What I delivered to you were sacred truths, but this that you tell me is mere fable and falsehood!'
>
> 'My Brother,' gravely replied the offended Indian, 'it seems that you have not been well grounded in the rules of civility. You saw that we, who practice these rules, believed your stories; why, then, do you refuse to credit ours?'.

As Deloria stresses, the creation stories and other basic myths of the huge number of tribes across Turtle Island (North America) differ as naturally and radically as the geography and ecology that inspired them. The name (indigenous, not European) of most tribes is best translated simply as 'the people of the place', and 'the place' is always the sacred center of the world. Not only does every tribe have such a center, tribes expect each other to be centered in the same way, anchored in their own fundamental natural experience and relationships. Only such religions, naturally diverse because naturally generated, are sustainable. 'This realization', as Yuchi social scientist Daniel Wildcat (2001, pp. 36–37) argues, 'offers a powerful way of thinking about the manner in which biological diversity and cultural diversity are intimately connected. It requires recognition that culture is an emergent property – that is, a reality resulting from a complex process containing a multitude of interactions. In short, cultures have causes, but not the kind most biologists or social scientists can easily test in a laboratory or replicate in linear causal models'.

Very many western scientists would accept as uncontroversial the cultural basis of religion, dismissing monopolistic claims to 'the truth' as supremacist and overinflated. Yet how many would extend the same inclusive courtesy, likewise rooted in cultural relativism, to alternative *scientific* truths, methods and worldviews? 'Science', Wilson (1998, p. 48) writes, 'is neither a philosophy nor a belief system' but simply 'a combination of mental operations…hit upon by a fortunate turn of history' and yielding 'the most effective way of learning about the real world ever conceived'.

But does this claim itself stand to reason?

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## 'Blackfoot Physics': a Western Scientist Thinks the Unthinkable

In 1994, with some trepidation, the British physicist F. David Peat challenged this monotheistic/missionary position, suggesting that Native American ways of learning about the real world were as 'scientific' – as effective, organized, fruitful and insightful – as the western way he had been trained in and taught to revere. Not scientific in the same way: another way of being scientific. In his introduction to *Lighting the Seventh Fire*, later reissued as *Blackfoot Physics*, Peat (2002, pp. xi–xii) grouped a large number of topics 'under the general rubric of Indigenous science, a term I have used following the lead of Pam Colorado, Leroy Little Bear, and others'. 'While I am comfortable', he adds, 'with this term *Indigenous science*' –

> I am also part of the Western science tribe and I can already sense the kind of objections that its members could make: 'Why do you use the term *science*? Native Americans don't have any science in the real sense of the word. They don't have an ordered system of investigation or rational theories of the universe as we do. Science is a specific and disciplined approach that was developed in the West. Indigenous people have traditions, folklore and mythology'.

This dismissive reflex, Peat (2002, pp. xii–xiv) argues, actually stems not from rigorous objective reasoning but a vigorous, if implicit, cultural prejudice:

> I believe the verdict of most 'hard-nosed' scientists would be that while Indigenous metaphysics and philosophy is certainly fascinating and, to the extent that it brings people close to nature, attractive; nevertheless, it should not be called a science. This is the inevitable conclusion within a worldview whose values are dominated by the need for progress, development, improvement, evolution, and the linear unfolding of time. Within such a world it stands to reason that things evolve, that automobile engines become more efficient, that new computers are faster, and that some societies are more highly developed than others.... Going along with this worldview is the need, when faced with alternatives, to decide which one is 'better' than the others. It goes without saying that when it comes to other people's cultures we are generally the ones doing the measuring ...

This either/or logic, the culturally habituated 'desire to compare, to measure, and to categorize in terms of better of worse' is, Peat (2002, p. xiv) notes, 'not the natural way of doing things within the Indigenous world'. Just as different myths and beliefs are respected as natural religious and spiritual phenomena – just as the world can have many 'centers' – so complementary scientific insights, and technological applications, should find room in the 'circle':

> As my friend [the anthropologist] Clem Ford has observed, in Labrador there was a traditional Indigenous way to hunt beaver and one that the European trappers used. Today both methods are used, and there is no sense that one method is 'better' than the other, or that one should replace the other. Rather, both methods are used, side by side.

*Blackfoot Physics* explores both the considerable commonality of western and indigenous science – their shared dedication to the basic, far-from-unique 'mental operations' of systematic investigation – and the fundamental differences (in theory, method and practice) at play. Appreciation of common ground, Peat (2002, p. 39) argues, is a necessary but insufficient, and potentially backward, step: 'One faces a great danger of believing that the only way of understanding Indigenous science would be to explain it in terms of the truths of western science. Thus, other cultures and ways of knowing are given their authenticity and validity, not from within the roots of their own tradition, but by using the yardstick of the...dominant West'. To maintain that indigenous science does indeed 'measure up' to many western standards – providing, via a 'disciplined approach to understanding and knowing', 'general laws and trustworthy methods for discovering truths' – is itself controversial to many of Peat's colleagues. But his real heresy lies elsewhere:

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> [I]t is not possible to separate Indigenous science from other areas of life such as ethics, spirituality, metaphysics, social order, ceremony, and a variety of other aspects of daily existence. Thus it can never be a 'branch' or a 'department' of knowledge, but rather remains inseparable from the cohesive whole, from a way of being and of coming-to-knowledge.... As far as Indigenous people are concerned, there is no need for them to justify their spirituality, their traditions, or their science to anything external to their society. Indigenous science does not need to explain itself to anyone (Peat, 2002, p. 241).

It does, however, have some important stories to tell.

## A Subtle and Sustaining Spirit: the 'Ecopsychology' of Indigenous Science

'Progress', generated and sustained by the twin impetus of industrialization and imperialism, defines the basic quest of modern western science. Seen through such a lens, the 'natural' role of science is to deliver these improvements and sustain the rate of 'modernization'. Traditional Chinese science, in contrast, reflects a cultural preoccupation with *balance*, seeking optimum harmony with the natural order, the Way or Tao, rather than maximum exploitation of natural resources. In a similar vein, the key cultural concept or heartbeat of Native American science is *spirit*, the animating energy and essence of life. While this spirit is universal – or, rather, *is* the universe – its effects can be felt (if one knows how to look) in the most local and intimate 'data' of existence. As the Pueblo ecologist and science writer Gregory Cajete (1999, p. 3) comments, there is nowhere, in fact, more extraordinary – more *spirited* – than the commonplace:

> The Americas are an ensouled and enchanted geography, and the relationship of Indian people to this geography embodies a 'theology of place,' reflecting the very essence of what may be called spiritual ecology. American Indians' traditional relationship to and participation with the landscape includes not only the land itself but the way in which they have perceived themselves and all else.... There is a metaphor that Pueblo people use, which, when translated into English, means 'that place that the People talk about.' This metaphor refers not only to a physical place but also a place of consciousness and an orientation to sacred ecology. Sacred orientation to place and space is a key element of the ecological awareness and intimate relationship that Indians have established with the North American landscape for 30,000 years or more.

To be 'native' to a place is, ideally, to live in deep attunement with its spirit. The function of 'Native science', correspondingly, is to facilitate this attunement, to foster what the Alaskan (Yup'ik) educationalist Oscar Kawageley (2001, p. 51) calls the 'ecopsychology' of indigenous inquiry. Rather 'than seeking to control natural reality' – the characteristic 'egopsychology' of so much western science in the centuries since the European conquest of America – Native Science, Cajete (2000, p. 17) argues, 'focuses its attention' upon 'inner natures', the 'rich textures and nuances of life' where matter and spirit, chaos and order, essence and entity, psyche and physics meet. What, then, are the guiding principles and practices of this spiritual 'science of the subtle'?

### The Primacy of Spirit

Many western-trained scientists will wonder what it means to explain and explore a naturally spiritual world. 'This essence', the *Tao Te Ching* (XXI, p. 49) insists, 'is quite genuine, and within it is something that can be tested'. Leroy Little Bear (2000, p. x) (Haudenosaunee) tells us how to look:

> The Native American paradigm is comprised of and includes ideas of constant motion and flux, existence consisting of energy waves, interrelationships, all things being animate, space/place, renewal, and all things being imbued with spirit.... The constant flux notion results in a 'spider web' network of relationships. In other words, everything is interrelated. If everything is interrelated, then all of creation is related. If human beings are animate and have spirit, then 'all my relations' must also be animate and must also have spirit. What Native Americans refer to as 'spirit' and energy waves are the same thing. All of creation is a spirit. Everything in creation consists of a unique combination of energy waves.

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*That* this is so is the Great Mystery, irreducible to any explanation, scientific or otherwise. But the web itself, *how* the spirit moves, can be seen and studied in great depth and detail.

In pointing to energy as the fundamental basis of the 'stuff' of life, Native science is fully in line with modern western concepts, encapsulated most famously in the $E = mc^2$ equation, of matter as condensed energy or light. These concepts, however, regard light and energy not as expressing any deeper forces but themselves made up of basic 'building blocks' (photons, electrons, nuclei, quarks etc.) below or beyond which there is, simply, nothing. These blocks, obeying strict physical laws and limits, combine to generate bigger and more complex structures (from cells to scientists) without guidance, aim, purpose or consciousness.

If, in contrast, you see all entities, down to the atomic and molecular level, as *units of spiritual information* – endowed with a creative capacity for combination and growth – then a very different, and much bigger, picture emerges.

## Spirit-in-Action: Information, Alliance and Evolution

During a discussion on the medicinal qualities of healing plants, the Mi'kmaq scholar Sa'ke'j Henderson asked David Peat a deceptively simple question: what is a molecule? As Peat tells the story,

> I offered him an explanation from modern science, that a molecule is a geometrical arrangement of atoms. Of course, he knew this sort of answer, but replied that a molecule was an alliance of spirits, and that when taken up into the body this alliance dissolves and takes up new configurations (Peat, 2002, p. 130).

'At the time', Peat (2002, pp. 130–131) confesses, 'I was inclined to bridge the gap between our two ways of thinking by calling on concepts from modern quantum physics. A molecule is an arrangement of atoms but it can also be represented by a wave function, which is, in a way, a sort of vibration of matter and energy. Maybe it is possible to think of the molecules that make up medicines as patterns of vibrations or more subtle forms of matter–energy. But, in that case, the same description would apply to a chair or table as to a medicine. The more I thought about it the more I realized that 'spirit' cannot really be reduced to our words *energy* or *matter* as they are currently understood in Western science'.

From the Native perspective of spiritual dynamics, evolution can be seen as the sustainable development of organic alliances: as a ripening and fruition of initial communion. Where Darwinist orthodoxy sees a blind fit between the random mechanics of natural selection and environmental constraints on survival, Indigenous science explores the creative potential of sacred energy, or basic units of spiritual information, to combine in new, surprising and often dramatic ways.

In the natural/human history of North America, corn perhaps provides the best example of this expressive potential. Reviewing the sudden appearance of radically new types of food (wheat, rice and corn) in different parts of the world, Peat (2002, p. 131) presents the conventional western wisdom – 'all that happened was that corn, wheat, and rice grasses happened to undergo a particularly striking, though random, genetic transformation' – and wonders whether 'Indigenous science' might offer 'a different kind of answer?'. Given that the 'traditional ways of the People' revolve around a reverential series of 'exchanges and compacts with the spirits of animals, plants, rocks, rivers, and trees', might not 'the grass that gave birth to corn' have been 'not simply a plant but a manifestation of a spirit or energy that moved within the complex pattern of relationships of the natural world'? If so, the developmental logic of sacred ecology suggested that when the People 'entered into direct relationship with the spirit of the corn, there was an exchange of obligations, a contract between the god of corn and the needs of the human race. Within this exchange a new alliance was struck that resulted in actual physical transformations'.

In 2001, the western-trained scientist Jane Mt. Pleasant (2001, p. 126) (Tuscorora) confessed at a conference 'For many years when I have entered a cornfield, I have known that I was walking among conscious living things – entities that were surely more than just plants. As an agronomist at a major land-grant university, that is certainly not something I readily reveal to my colleagues, students, or even to the farmers with whom I work'. 'But', she added,

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> I know that these feelings are rooted in an understanding of the natural world and of corn that extends back generations and reflects knowledge from another vantage point, a Native perspective.... I love working with corn, and as an agronomist I am in awe of its productivity. But I also know that it represents much more than a prolific agricultural crop. It is an enormous gift to human beings and speaks of life and connection to the earth in ways that are profoundly simple and complex at the same time.

As Mt. Pleasant (2001, p. 129) details, this subtle simplicity pervades the beautiful 'Three Sisters' system of corn–beans–squash cultivation indigenous to various regions of the Americas. Defined in western terms, the system is impressive enough:

> Beans, because they are legumes, add nitrogen to the soil that the other two plants need. In other words, they add free fertilizer. The corn, in turn, provides physical support for the beans.... Now the squash, because it grows low to the ground and has very big leaves, reduces the ability of weeds to grow and interfere with the food crops. Finally, the three crops eaten together provide a very balanced diet of vitamins, minerals, carbohydrates, and the full complement of amino acids for protein.

Yet much is lost in this translation. 'When I enter the cornfield today', Mt. Pleasant concludes, 'I feel the corn spirit'. In the western tradition, however, while the spiritual dimension is something a scientist may personally acknowledge and experience, it is not something he or she studies. In the Native tradition, science *is* a rational engagement with the spiritual basis and fabric of reality. Without such 'sacred research' or 'spiritual empiricism' by generations of indigenous people, would Corn ever have been born or, indeed, found her sisters?

## Creative Chaos: the Open Circle

'Chaos theory', shorthand for a range of new approaches to change and transformation in complex natural systems, has been widely proclaimed as a major breakout from rigidly reductionist, insufficiently subtle western scientific concepts. In their classic popularization *Order Out of Chaos*, Ilya Prigogine and Isabelle Stengers (1984, p. 9) summarized the main features of the shift:

> Our universe has a pluralistic, complex character. Structures may disappear, but also they may appear.... Today we see everywhere the role of irreversible processes, of fluctuations. The models considered by classical physics seem to us to occur only in limiting situations such as we can create artificially by putting matter into a box and then waiting till it reaches equilibrium. The artificial may be deterministic and reversible. The natural contains essential elements of randomness and irreversibility. This leads to a new view...in which matter is no longer the passive substance described in the mechanistic world view but is associated with spontaneous activity. This change is so profound that...we can really speak about a new dialogue of man with nature.

In the Native American tradition, where this 'new' dialogue has been sustained for millennia, the spontaneity so stunning to modern scientists is the formative principle of spirit-in-action, the creative realization of sacred potential. Chaos, in Cajete's (2000, p. 16) summary, is 'both movement and evolution', the 'process through which everything in the universe becomes manifest and then returns to the chaos field'. This 'flux, or ebb and flow, appears in everything', not only enveloping us 'at all times and in all places' but connecting, across time and space, all life forms and cycles in a single, radically integrated web, or whole: the Great Spirit. 'No wonder', as Cajete states, 'Native science envisions the spirit of the natural world alive with disorder and all the mystery of mirrored relationships'.

'Chaos', then, is really a channel of communication between outside and inside, being and becoming, the psychic and the physical: the circular breathing of spirit through matter. At the level even of atomic activity, Prigogine and Stengers (1984, p. 17) marvel, 'we can speak of a new coherence, of a mechanism of "communication" among molecules', with 'such communication' serving as 'the very basis of the definition of a biological system'.

And where does that system stop? If molecules communicate – if materialized energy is spiritual information – then where does the line fall between 'living' and 'non-living', 'animate' and 'inanimate'? If these divisions are

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more apparent than real, then the ecological function served by 'sacred objects' in Native tradition – stones, eagle feathers, medicine bundles etc. – becomes clear: to remain open, through reverence, to messages and signals from the 'real', that is the *spirit*, world.

In many tribes, the relationship between flux and form, repetition and renewal, innovation and tradition is represented by the medicine wheel, or sacred hoop, symbolizing the circular breathing and centering power of the four directions, winds and seasons. Because of the immense energies and infinite possibilities created by this constant motion, the circle, as Peat (2002, p. 171) notes, 'is always left open so that the new may enter'. 'Nothing', except the wheel itself, 'is permanent, no situation is ever fixed, and no category is ever closed. The trickster is ever present in all aspects of Indigenous science'.

The most advanced science in indigenous cultures is practiced by the healers and shamans, men and women with a particularly strong connection to what Deloria (2006, p. 197) called the 'energetic mind undergirding the physical world'. Many of their most sophisticated and effective techniques – dream-diagnosis, foreknowledge, time-travel, action-at-a-distance etc. – are categorized by western science (when not dismissed simply as fraud) as 'paranormal'. Likewise, the uncanny coincidences, or synchronicities, common to all cultures – together with many other examples of apparent mind–matter communication – remain theoretically inexplicable, more often ignored than investigated. The Trickster, certainly, is subtle, but, as Deloria (2006, p. 194) argues, we ignore him at our peril.

## Conclusion: Science and Survival

We live in a world imperiled by our failure to 'keep the circle open': to maintain meaningful relations between human and non-human nature and between science and spirit. Despite the 'new thinking' of chaos theory, quantum physics, ecology, systems theory and other disciplines, the 'modern obsession of being in control and the dream of eliminating uncertainty through control of nature' (seen most clearly, perhaps, in genetic engineering and cloning) remains 'the underlying philosophical premise of Western science' (Cajete, 2000, p. 16).

In order for a 'new dialogue' between 'man and nature' to really occur in the west – a 'west' which, courtesy of neo-liberal economic globalization, is rapidly becoming *the* world – new channels of communication urgently need to be opened with alternative scientific traditions. It is time to recognize that all scientific worldviews are products of the culture within which they are embedded; they are all, in short, *ethno*sciences. Every worldview is necessarily built upon metaphysical beliefs. It is, for example, as metaphysical to assert that the natural world is nothing more than the interactive collection of non-living, non-purposeful components as it is to claim that the natural world is alive and that even the smallest action can exert enormous influence on the whole. While some defenders of western science will respond that some significant shifts beyond the mechanistic paradigm are now being made, it is also important to recognize both the tenacity and persistence of the reductionist grip on the western scientific mind and the traumatic consequences of such a dissective and violent worldview on the biosphere.

Despite, or perhaps because, of its impressive range of insights and achievements, Indigenous science is grounded in a double sense of responsibility: the responsibility of humans to live like *People*, to act in accordance with the spiritual information within and around them (which it is the role of a sustainable science to explore and explain); and the ability of humans *to* respond, creatively and communally, to challenge and change (a power seen as inherent to all life).

And here we return to Simonelli's (1994, p. 37) characterization of Indigenous science as 'full-spectrum', surpassing western understandings limited to the physical and mental, while ignoring the emotional and spiritual, dimensions of existence. Simonelli is, we believe, correct in his belief that *sustainable science* can be a roadway to environmental justice. Being open-minded about alternative worldviews is a crucial first step on such a journey. Fortunately, there are many worthy guides, among them Cajete, to follow:

> As we begin our journeys to find the Indigenous mind-set that will allow for sustainable (and even restorative) ways of living at all levels, we must think about who we are and who we represent. Understand that each of us in our own small way is a vital link within the context of creating and remembering the reciprocal relationships that sustain and enliven the earth, flora and fauna, and human beings – in brief, local to global ecology.

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> …As you look to and imagine climbing the primordial mountain, reflect on your life and what it means to be educated and intelligent. As you move down from the mountain down a pathway to resume your journey guided by ecological thought, think about the journey of your life in relationship to a 'place.' It is the task of each of us to 'look to the mountain' and build a vision of a sustainable future for the people inhabiting Mother Earth in the year 2000, 3000, and beyond (Cajete, 1999, pp. 19–20).

A shift in thinking that grants equal standing in any discussions surrounding knowledge of the natural world to other scientific worldviews will have a number of important consequences, of which the most important is the attendant understanding of the very high human and environmental costs of the prevailing western worldview. For, along with the growth in the belief that there is only one right way to investigate the natural world, came the prejudice that any group of people who did not see the world in the same manner were in need of guidance, usually in the form of colonial domination, to wrest them from their myths and superstitions. This perspective continues to underlie the supremacist view of those convinced that there really is only *one* science; a conviction, alas, shared even by those persuaded that we can learn from the 'knowledge' of other worldviews. Exposing the historically deep relationship between capitalism, racism, imperialism and institutionalized western scientific practice is a vital step toward embracing the authentically sustainable science practiced in Native American and other indigenous traditions.

Encouraging inquiry into the seemingly intractable problems faced today (ecological deterioration being perhaps the most urgent) requires a humility and an openness to learn from others who have a long history of holistic inquiry into the workings of the natural world. Additionally, it requires an end to the demand that all knowledge must be validated by western scientific method if it is to be taken seriously.

For many in the west, even to acknowledge the existence of other sciences – other spirits of inquiry – poses a formidable challenge. But if we don't have the ability to respond, how much longer can we hope to survive?

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