Chapter prepared for a UNESCO-SAARMSTE book project on methodologies for researching mathematics, science and technological education in societies in transition, January 2005.

Geophilosophy and methodology: science education research in a rhizomatic space

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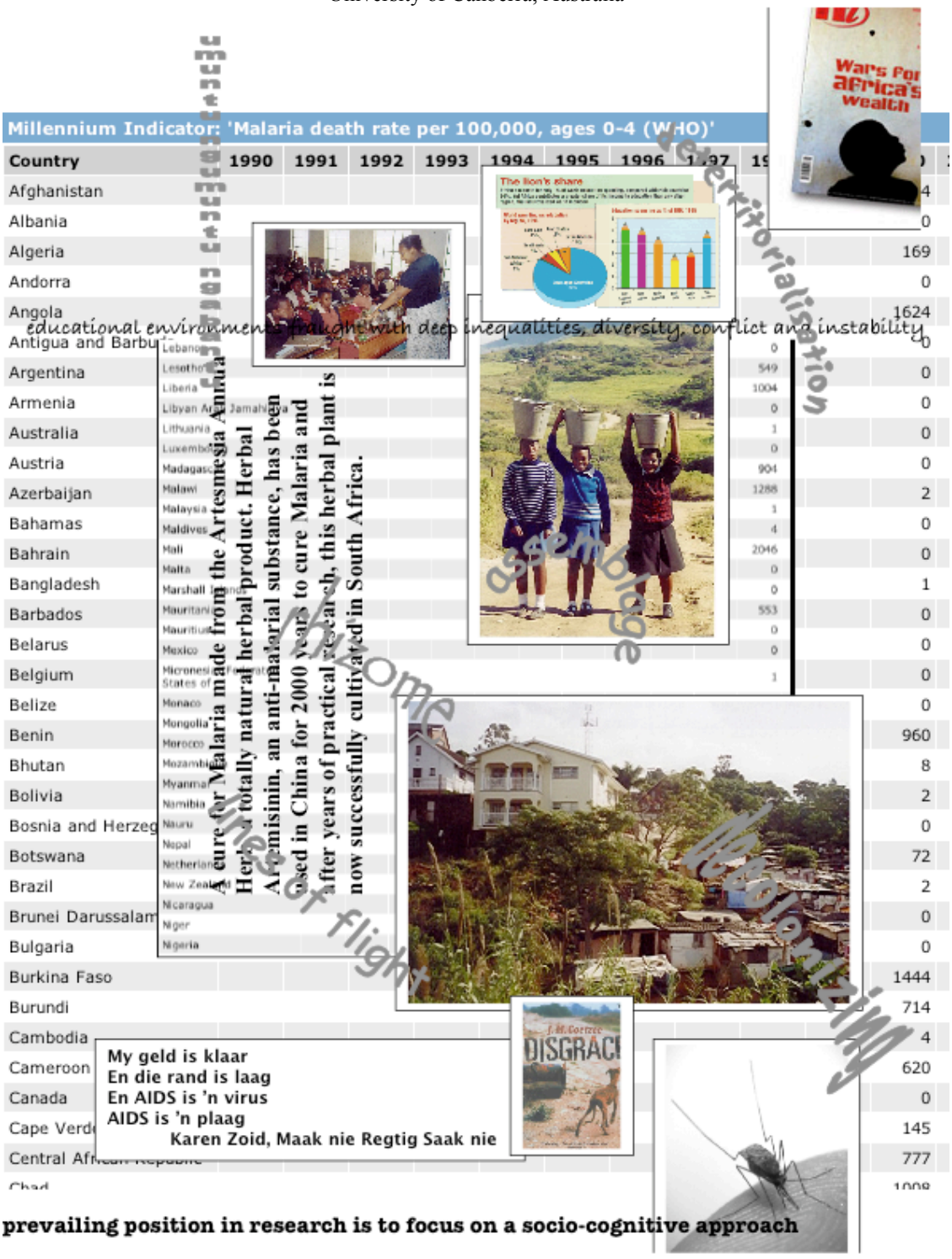

FIGURE 1: 'If this is an awful mess… then would something less messy make a mess of describing it?' (illustration inspired by – and caption quoted from – John Law, 2003, pp. 2-3)

Methodology and mess

Figure 1 is my attempt to represent a mess. Of course, it's not 'really' a mess – it's too sparse and contrived to be that – but my purposes will be served if you can *imagine* the mess I'm trying to represent here. When I think about what the editors of this book invited contributors to do – to focus on the challenges for developing research methodologies that are appropriate and relevant to societies undergoing major changes, especially characteristic of the 'developing world' – I imagine a mess. Developing what they call 'a scholarship in research that is responsive and relevant to rapidly changing educational environments that are fraught with deep inequalities, diversity, conflict and instability' means developing methodologies for knowing mess that helps us to understand the politics of mess and messiness. My mess is made from samples of texts (in the broadest sense of the term) that represent some of my understandings of the inequalities, diversities, conflicts and instabilities that constitute science education and research in regions such as southern Africa.

I should say immediately that I do not think that the 'developing world' is necessarily any messier than whatever world it is Other to. Educational environments that are 'fraught with deep inequalities, diversity, conflict and instability' are certainly not unknown in Australia and other 'developed' nations, although they may be less pervasively and persistently visible (in colloquial terms they are less 'in your face') than in many southern African nations. Moreover, the messiness that presents itself to educational researchers in Australia has some qualitatively different characteristics from that which confronts our colleagues in, say, South Africa. For example, we live with the cultural residues of the White Australia policy rather than of apartheid, but it is relatively easy for Australian researchers to ignore the historical traces of institutionalised racism as a component of our mess because they manifest themselves in more subtle ways than they do to South Africans.

However, the particularities of the image of mess that I have assembled in figure 1 are not important. Imagine your own picture of the messiness of mathematics, science and/or technology education in southern Africa, and then reflect on the caption I have borrowed from Law (2003): 'If this is an awful mess… then would something less messy make a mess of describing it?' (p. 3). This is a rhetorical question. Law wants you to agree that *simplification does not help us to understand mess.*

Law (2003) asserts (and I concur) that: 'the world is largely messy' and that 'contemporary social science methods are hopelessly bad at knowing that mess'; furthermore, 'dominant approaches to method work with some success to repress the very possibility of mess' (p. 3). He invites us to imagine method more imaginatively, to imagine what method – and its politics – might be 'if it were not caught in an obsession with clarity, with specificity, and with the definite' (p. 3). Law (2003) argues that social science inquiry is mostly 'a form of hygiene':

> Do your methods properly. Eat your epistemological greens. Wash your hands after mixing with the real world. Then you will lead the good research life. Your data will be clean. Your findings warrantable. The product you will produce will be pure. Guaranteed to have a long shelf-life. So there are lots of books about intellectual hygiene. Methodological cleanliness. Books which offer access to the methodological uplands of social science research…
>
> In practice research needs to be messy and heterogeneous. It needs to be messy and heterogeneous, because that is the way it, research, actually is. And also, and more importantly, it needs to be messy because that is the way the largest part of the world is. Messy, unknowable in a regular and routinised way. Unknowable, therefore, in ways that are definite or coherent. That is the point of the figure. Clarity doesn't help. Disciplined lack of clarity, that may be what we need (p. 3).

In *After Method: Mess in Social Science Research*, Law (2004) elaborates upon this argument at much greater length. He does so in his own way, drawing on his immersion in the discourses of actor-network theory (ANT) and its successor projects. I also find ANT to be very generative in thinking about methodology but my current preference is to engage messy and heterogeneous objects of inquiry through the frames and figurations provided by Deleuze and Guattari's 'geophilosophy', especially their concepts of *rhizome* and *nomad*.[1]

Why geophilosophy?

> Nietzsche founded geophilosophy by seeking to determine the national characteristics of French, English and German philosophy. But why were only three countries collectively able to produce philosophy in the capitalist world?
>
> —Gilles Deleuze & Félix Guattari, *What is Philosophy?* (1994), p. 102

In *What is Philosophy?* – the last book that French poststructuralist philosopher Gilles Deleuze and psychoanalyst Félix Guattari wrote together – they map the 'geography of reason' from pre-Socratic times to the present, a geophilosophy describing relations between particular spatial configurations and locations and the philosophical formations that arise therein. They characterise philosophy as the *creation* of concepts through which knowledge can be generated. As Michael Peters (2004) points out, this is very different from the approaches taken by many analytic and linguistic philosophers who are more concerned with the *clarification* of concepts:

> Against the conservatism, apoliticism and ahistoricism of analytic philosophy that has denied its own history until very recently, Deleuze and Guattari attempt [a] geography of philosophy – a history of geophilosophy – beginning with the Greeks. Rather than providing a history, they conceptualise philosophy in spatial terms as *geophilosophy*. Such a conception immediately complicates the question of philosophy: by tying it to a geography and a history, a kind of historical and spatial specificity, philosophy cannot escape its relationship to the City and the State. In its modern and postmodern forms it cannot escape its form under industrial and knowledge capitalism (p. 218).

Deleuze and Guattari created a new critical language for analysing thinking as flows or movements across space. Concepts such as *assemblage, deterritorialisation, lines of flight, nomadology,* and *rhizome/rhizomatics* clearly refer to spatial relationships and to ways of conceiving ourselves and other objects moving in space. For example, Deleuze and Guattari (1987) distinguish 'rhizomatic' thinking from 'arborescent' conceptions of knowledge as hierarchically articulated branches of a central stem or trunk rooted in firm foundations. As Umberto Eco (1984) explains, 'the rhizome is so constructed that every path can be connected with every other one. It has no center, no periphery, no exit, because it is potentially infinite. The space of conjecture is a rhizome space' (p. 57).

The space of educational research can also be understood as a 'rhizome space'. Rhizome is to a tree as the Internet is to a letter – networking that echoes the hyper-connectivity of the Internet. The material and informational structure of a tree and a letter is relatively simple: a trunk connecting two points through or over a mapped surface. But rhizomes and the Internet (see figs. 1 and 2) are infinitely and continually *complicating*. They are irreducibly messy.

Figure 1: A tangle of rhizomes
(Drawing: Warren Sellers)

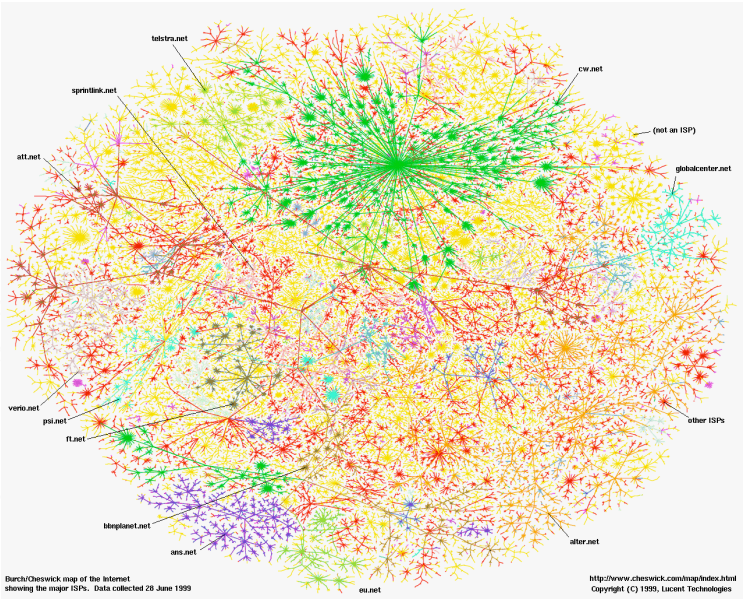

Figure 2: A map of the Internet
(http://research.lumeta.com/ches/map/gallery/isp-ss.gif)

Commencing a rhizome (shaking the tree)

> *Souma yergon, sou nou yergon, we are shaking the tree*[2]
>
> —Peter Gabriel & Youssou N'Dour, 'Shaking the Tree' (1989)

> …rhizomes are anomalous becomings produced by the formation of transversal alliances between different and coexisting terms within an open system.
>
> —Gilles Deleuze & Félix Guattari, *A Thousand Plateaus* (1987), p. 10

I interpret Deleuze and Guattari's (1987) figurations of *rhizome* and *nomad* as tools for 'shaking the tree' of modern Western science,[3] science education curricula and science education research. Thinking rhizomatically and nomadically destabilises arborescent and sedentary conceptions of knowledge as hierarchically articulated branches of a central stem or trunk rooted in firm and fixed foundations. The materials from which we can commence making such rhizomes are readily to hand, and can be found among the many and various arts, artefacts, disciplines, technologies, projects, practices, theories and social strategies that question and challenge the monocultural understandings of science reproduced by many science education programs and professors.[4] These materials include not only academic discourses/practices – such as feminist, queer, multicultural, sociological, antiracist, and postcolonialist cultural studies and/or science studies – but also the products and effects of popular arts and arts criticism.[5]

Peter Gabriel and Youssou N'Dour's song, 'Shaking the Tree', is emblematic of my project because it is a call to change and enhance lives that complements Deleuze and Guattari's geophilosophy. Both Gabriel and N'Dour compose and perform songs about taking action to do something about particular problems in the world, and Deleuze (1994) similarly argues that concepts 'should intervene to resolve local situations' (p. xx). 'Shaking the Tree' is a North-South collaboration (Gabriel is British, N'Dour is Senegalese) between two men who celebrate and affirm the women's movement in Africa, where patriarchal traditions and gender discrimination remain pervasive. Thus, as a popular song, 'Shaking the Tree' represents marginalised knowledges[6] in form as well as content – both popular media/culture

and non-Western knowings tend to be ignored or devalued within many forms of Western science education, including those that have been imported by 'developing' nations. These exclusions contribute to what Sandra Harding (1993) calls an increasingly visible form of 'scientific illiteracy', namely, 'the Eurocentrism or androcentrism of many scientists, policymakers, and other highly educated citizens that severely limits public understanding of science as a fully social process' (p. 1); she continues:

> In particular, there are few aspects of the 'best' science educations that enable anyone to grasp how nature-as-an-object-of-knowledge is always cultural… These elite science educations rarely expose students to systematic analyses of the social origins, traditions, meanings, practices, institutions, technologies, uses, and consequences of the natural sciences that ensure the fully historical character of the results of scientific research. (p. 1)

I suggest that the limited exposure to which Harding refers results, in part, from concentrating students' attention on two main ways of representing science, namely, documentary media (especially the science textbook and its equivalents in other media) and the 'theatre' of school laboratory work (see Noel Gough, 1993b, 1998b). Representations of science in the arts and popular media – and the wide variety of contributions that they make (or might make) to 'public understanding of science as a fully social process' – tend to be given much less attention.[7] But I argue that a contemporary media genre such as SF – an acronym that designates much more than 'science fiction'[8] – provides many of the most convincing and publicly accessible demonstrations of 'how nature-as-an-object-of-knowledge is always cultural'. Andrew Ross (1996) alludes to this capacity of SF to illuminate the social and cultural meanings and consequences of scientific research when he writes: 'Outside of *Jurassic Park,* I have yet to see a critique of Chaos Theory that fully exposes its own kinship with New Right biologism, underpinned by the flexible economic regimes of post-Fordist economics' (p. 114).[9]

In his Preface to *Difference and Repetition* Deleuze (1994) asserts that a text in philosophy 'should be in part… a kind of science fiction' (p. xx) in the sense of writing 'at the frontiers of our knowledge, at the border which separates our knowledge from our ignorance and transforms the one into the other' (p. xxi). Much of my previous research and writing on science education has been concerned with demonstrating the possibilities of 'synthetically growing a post-human curriculum' – to quote John Weaver's (1999) interpretation of my work – by expanding and diversifying the cultural materials and tools that science educators deploy in their curriculum practices.[10] Here I will explore some of the immanent but hitherto unexplicated implications of this work and demonstrate how Deleuzean concepts might generate transformative possibilities for theorising science education and performing science education research. Like Laurel Richardson (2001), 'I write in order to learn something that I did not know before I wrote it' (p. 35), and so this text too is 'a kind of science fiction' that rewrites my philosophy of science education as geophilosophy.

For example, I have previously argued for adapting to the natural sciences a proposal that Richard Rorty (1979) makes in respect of the social sciences: 'If we get rid of traditional notions of "objectivity" and "scientific method" we shall be able to see the social sciences as continuous with literature – as interpreting other people to us, and thus enlarging and deepening our sense of community' (p. 203). I argued that seeing the natural sciences also as 'continuous with literature' means, to paraphrase Rorty, seeing both science and literature as interpreting the earth to us and thus 'enlarging and deepening our sense of community' with the earth. The consequences for science education research would then best be understood in terms of storytelling – of abandoning what Harding (1986) calls 'the longing for "one true story" that has been the psychic motor for Western science' (p. 193). Rather, we should

deliberately treat our stories of science education research as metafictions – self-conscious artefacts that invite deconstruction and scepticism (Gough, 1993a, p. 622).

I initially drew my support for this argument from scholars who work at the intersections of literary criticism and science studies. For example, David Porush (1991) argues persuasively that in the world of complex systems revealed to us by postmodernist science – protein folding in cell nuclei, task switching in ant colonies, the nonlinear dynamics of the earth's atmosphere, far-from-equilibrium chemical reactions, etc. – 'reality exists at a level of human experience that literary tools are best, and historically most practiced, at describing' and that 'by science's own terms, literary discourse must be understood as a superior form of describing what we know' (p. 77). Such arguments are consistent with those offered by scholars whose work is identified with cultural studies of science (e.g., Donna J. Haraway, 1994; Sandra Harding, 1994; Joseph Rouse, 1993), the discursive production of science(e.g., Charles Bazerman, 1988, 1999), and sociological studies of scientific knowledge (e.g., Harry Collins & Trevor Pinch, 1998; Bruno Latour, 1987, 1988, 1993, 1999; Bruno Latour & Steve Woolgar, 1979; Steven Shapin, 1994; Steve Woolgar, 1988). Science education researchers who have drawn on these areas of inquiry include Jay Lemke (1992), who queries the defensibility of the 'simulations and simulacra of science' that students encounter in conventional school science courses (see also Jay L. Lemke, 1990, 2001). Researchers who have paid particular attention to representations of science in popular media/culture include Peter Appelbaum (1995; Peter Appelbaum, 2000) see also (Peter Appelbaum & Stella Clark, 2001) and Matthew Weinstein (1998a; 1998b; 2001a; 2001b).

Although I agree that literary and artistic modes of representation might be more defensible for many purposes in science education than the supposedly more 'objective' accounts of professional scientists and textbook authors, I now want to go beyond debating the merits and demerits of competing representationalist philosophies. In this previous work I moved away from the fixity and centeredness of a conventional scientist's (or mainstream literary scholar's) point of view, but I still worked within the limits of grounded positions, albeit positions found as I moved (in Rorty's terms) from one temporary standpoint to another along various continua between literature and science.[11]

Thus, in this chapter I explore what it means to be becoming nomadic in theorising science education, to liberate science education research from the sedentary points of view and judgmental positions that function as the nodal points of Western academic science education discourse. What happens when we encourage random, proliferating and decentred connections to produce rhizomatic 'lines of flight' that mesh, transform and overlay one another? Imagining knowledge production in a rhizomatic space is particularly generative in postcolonialist educational inquiry because, as Patricia O'Riley (2003) writes, 'Rhizomes affirm what is excluded from western thought and reintroduce reality as dynamic, heterogeneous, and nondichotomous' (p. 27), and this is precisely what I will attempt to demonstrate here by commencing a rhizome, a textual assemblage that I hope will generate questions, provocations and challenges to some of the dominant discourses and assumptions of contemporary science education research.

The approach I adopt here is inspired by the method Haraway (1989) uses in the final chapter of *Primate Visions*, wherein she 'reads' primatology as science fiction, and vice versa:

> Placing the narratives of scientific fact within the heterogeneous space of SF produces a transformed field. The transformed field sets up resonances among all of its regions and components. No region or component is 'reduced' to any other, but reading and writing practices respond to each other across a structured space. Speculative fiction has different tensions when its field also contains the inscription practices that constitute scientific fact.

> The sciences have complex histories in the constitution of imaginative worlds and of actual bodies in modern and postmodern 'first world' cultures (p. 5).

I depart from Haraway by imagining the 'transformed field' I produce as a nomadic space rather than a 'structured space'. However, the final sentence in the quotation above opens a connection to the rhizome that I commence here, because it also resonates with 'Shaking the Tree'. The sciences not only have complex histories in the constitution of imagined worlds and actual bodies in modern and postmodern 'first world' cultures, but also in 'third world' cultures – and the silences about such histories *and geographies* in 'first world' science education textbooks and science journalism are aspects of scientific illiteracy that are doubly troubling when they are exported to (or imported by) 'developing' nations under the guise of 'best' practice (where 'best' is usually a euphemism for 'West').

Mosquito rhizomatics

> We are writing this book as a rhizome. It is composed of plateaus… Each morning we would wake up, and each of us would ask himself what plateau he was going to tackle, writing five lines here, ten lines there. We had hallucinatory experiences, we watched lines leave one plateau and proceed to another like columns of tiny ants.
>
> —Gilles Deleuze & Félix Guattari, *A Thousand Plateaus* (1987), p. 22.

> [Rhizomes] implicate rather than replicate; they propagate, displace, join, circle back, fold. Emphasizing the materiality of desire, rhizomes like crabgrass, ants, wolf packs, and children, de- and reterritorialize space.
>
> —Patricia O'Riley, *Technology, Culture, and Socioeconomics* (2003), p. 27.

Ants have already inspired me to make a rhizome in another place (see Noel Gough, 2004c) so now I will allow mosquitoes to suggest connections, lines of flight and opportunities for deterritorialisation. I commenced these 'mosquito rhizomatics' in July 2004 when a number of initially separate threads of meaning – a research article in *Public Understanding of Science*, a *Time* magazine cover story, recollections of an SF novel and of various studies in the sociology of scientific knowledge read over the past decade and more – coincided, coalesced, and eventually began to take shape as an object of inquiry.

The *Public Understanding of Science* article that caught my attention was Stephen Norris, Linda Phillips and Connie Korpan's (2003) empirical-analytic study of university students' interpretations of scientific media reports, which followed an earlier (and similarly designed) study of high school science students by two of these authors (Stephen P. Norris & Linda M. Phillips, 1994). Both studies sought to measure certain aspects of the students' interpretations of the meanings of five media reports, with particular reference to the degree of certainty with which various statements were expressed, the scientific status of statements (e.g., cause, observation, method) and the role of statements in each report's chain of reasoning (e.g., justifications for what ought to be done, evidence for other statements made in the report). According to the measurement instruments devised by these researchers, both high school and university students had difficulties with all aspects of the task, displaying a certainty bias in their responses to questions regarding truth status, confusing cause and correlation, and also confusing statements reporting evidence with statements reporting justifications. Although Norris, Phillips and Korpan (2003) admit that they designed their research to *assess* the interpretive abilities of high school students (rather than to 'explain' them), they nevertheless speculated that: 'The performance of these students suggests that the science curriculum had

not prepared them well to interpret media reports of scientific research' (p. 125). The authors attempted to address this limitation in their study of university students by obtaining additional data, such as participants' self-assessments of their background knowledge and interests and the reading difficulty they ascribed to each report. Within the analytic framework of a correlational study, these self-assessments 'explained' virtually none of the variance in the interpretive performances of the university students who, 'in general, had an inflated view of their ability to understand the five media reports' (p. 123). Norris, Phillips and Korpan (2003) conclude:

> Generally, science textbooks used in high school and early university do not provide information on why researchers do their research, on the histories of research endeavors, on the motivation underlying particular studies, on how scientific questions arise out of the literature or anomalous events, or on the texture and structure of the language used in science. By contrast, scientific media reports often include the history and background to studies, information on the motivation for the reported research, and a variety of textured and structured language. In short, there is a mismatch. If media reports of science are to serve as an effective source of life-long scientific learning and support for public deliberation on science-related social issues, then much change is needed in high school and university science instruction to make this dream a reality. Otherwise, highly educated individuals having, as most of them do, little education specifically in science will help to run the major systems of our society without the benefit of being able to interpret and evaluate simple media reports of the latest scientific developments upon which those systems crucially depend (p. 141).

Norris, Phillips and Korpan's (2003) characterisations of the differences between science textbooks and scientific media reports converge with my own and others' qualitative studies of these types of textual materials (see, for example, (Sharon Dunwoody, 1993), Gough, 1993b). But asserting that these differences constitute a 'mismatch' begs the question of why these distinct genres of science/education text should 'match' at all, given that science textbooks and scientific media reports serve different purposes. I suspect that what Norris, Phillips and Korpan might be suggesting here is that science instruction in high schools and universities equips students to interpret science textbooks but not scientific media reports, which therefore diminishes the potential effectiveness of the latter as resources for life-long scientific learning and for more increased public understanding of science and science-related social issues. However, positioning scientific media reports as some sort of desirable Other to science textbooks leaves unanswered the question of whether either type of text addresses the Eurocentrism and/or androcentrism to which Harding (1993) refers.

Shortly after reading Norris, Phillips and Korpan's (2003) article, I also read 'Death by Mosquito', a cover story in *Time* magazine (Christine Gorman, 2004). The story begins by pointing out that malaria sickened 300 million people in 2003 and killed 3 million, most of them under age 5. In the same period AIDS killed just over 3 million people. 'What makes the malaria deaths particularly tragic', Gorman writes, 'is that malaria, unlike AIDS, can be cured'. She asks: 'Why isn't that happening?' Some selected excerpts from her story follow:

> Countries in sub-Saharan Africa have suffered the brunt of this renewed assault, but nations in temperate zones, including the U.S., are not immune…
>
> Doctors have long suspected that the malaria problem was getting worse, but the most searing proof has come to light in just the past year. Researchers believe the average number of cases of malaria per year in Africa has quadrupled since the 1980s. A study in the journal Lancet last June reported that the death rate due to malaria has at least doubled

> among children in eastern and southern Africa; some rural areas have seen a heartbreaking 11-fold jump in mortality…
>
> Recognition of malaria's toll on the global economy is growing. Economist Jeffrey Sachs, director of Columbia University's Earth Institute, estimates that countries hit hardest by the most severe form of malaria have annual economic growth rates 1.3 percentage points lower than those in which malaria is not a serious problem. Sachs points out that the economies of Greece, Portugal and Spain expanded rapidly only after malaria was eradicated in those countries in the 1950s. In other words, fighting malaria is good for business – as many companies with overseas operations have long understood…
>
> To better understand why malaria has become such a threat and what can be done to stop the disease, it helps to know a little biology.

I compared the 'little biology' provided by the *Time* article with the single page on malaria in Victoria's current year 12 biology textbook, *Nature of Biology Book 2* (Judith Kinnear & Marjory Martin, 2000), which devotes one of its sixteen chapters to 'Disease-Causing Organisms'. The two texts exemplify the generic differences to which Norris, Phillips and Korpan (2003) draw attention, with the *Time* article providing more information on the history of research on malaria and on the social, political and economic motivations for current research efforts. In most other respects, both sources tell a very familiar story: malaria is caused by protozoan parasites and is spread among humans by mosquitoes. The *Nature of Biology* account provides little more than a brief description of the parasite's lifecycle and brief biological explanations for the symptoms of mosquito bites (itchy swellings) and malaria (chills and fevers) and concludes with the following paragraph:

> Although drugs are available for the treatment of malaria, a complete cure is difficult. This is because the parasite can remain dormant for many years in the liver before becoming active again. Different drugs are used against the different stages of the malarial parasite. Malaria is still one of the most serious infections in the world and is particularly common in some tropical and sub-tropical areas. The *Anopheles* mosquito, the main carrier of malaria, is common in these areas. Australians travelling to such areas are advised to take anti-malarial drugs both before, during and after visiting the area although this does not guarantee prevention of infection (Kinnear & Martin, 2000, p. 209).

Other than advising Australian travellers to take precautions against malaria, Kinnear and Martin say nothing about what makes it 'one of the most serious infections in the world' – nowhere do they mention that malaria can be fatal, or that it bears comparison with AIDS, tuberculosis and dysentery in currently being among the world's deadliest diseases. Not only do they tacitly diminish malaria's effects but also, to paraphrase Harding (1993), there is little in Kinnear and Martin's account that might enable readers to understand at least some of malaria's cultural determinants. The *Time* article provides explanations for the increased vulnerability of pregnant women and young children, and for variations in human resistance to the disease. *Time* also addresses issues on which *Nature of Biology* is completely silent, such as how malaria parasites have become increasingly drug-resistant, why controlling anopheles mosquitoes in tropical regions is so difficult, and why the most effective pharmaceutical responses currently available are beyond the financial resources of the poorest nations of the world, particularly those in Africa. Admittedly, *Time's* treatment of malaria is more than twice as long as that found in *Nature of Biology*, but Kinnear and Martin could still have made different choices about what to include in (and exclude from) their account. For example, is alerting Australians to the risks of malarial infection if they travel to certain regions really more important than alerting them to the massive human tragedy of millions

dying of malaria in the West's tourist destinations and, moreover, that this is a tragedy that Western nations have the resources to ameliorate?

However, neither *Time* nor *Nature of Biology* provide readers with any alternatives to understanding malaria within what David Turnbull (2000) calls 'the knowledge space of Western laboratory science' wherein 'malaria is made to appear as a natural entity in the world, …embedded in a conceptual framework which portrays the discovery and elucidation of its causes as occurring within the gradual unfolding of an emanent scientific logic, which will culminate in a physicochemical solution to the malaria problem' (p. 162). To step outside this logic requires, in Deleuze's terms, an act of *deterritorialisation* which, as Kaustuv Roy (2003) describes it, is 'a movement by which we *leave the territory*, or move away from spaces regulated by dominant systems of signification that keep us confined to old patterns, in order to make new connections' (p. 21; italics in original). Roy (2003) continues:

> To proceed in this manner of deterritorializing, we make small ruptures in our everyday habits of thought and start minor dissident flows and not grand 'signifying breaks,' for grand gestures start their own totalising movement, and are easily captured. Instead, small ruptures are often imperceptible, and allow flows that are not easily detected or captured by majoritarian discourses (p. 31).

I am disposed to produce such 'small ruptures' and 'minor dissident flows' by reading questions for inquiry in science education within an intertextual field that includes SF. In this instance, as I read the *Time* and *Nature of Biology* texts, I also recalled reading *The Calcutta Chromosome: A Novel of Fevers, Delirium, and Discovery*, a mystery thriller in the SF sub-genre of alternative history by Amitav Ghosh (1997). Like most works of SF, Ghosh's novel offers a semiotic space that is *not*, to recall Roy's words, 'regulated by dominant systems of signification', and that therefore invites readers to think beyond the sign regimes of Western laboratory science. Ghosh's novel becomes another filament in my mosquito-led rhizome by offering a speculative counterscience of malaria that connects with (but does not replicate) the 'real' history of Western medicine's explorations of the disease. For example, one of the key protagonists in Ghosh's alternative history is Ronald Ross, whose work on the lifecycle of the plasmodium parasite for the British Army's Indian Medical Service in late nineteenth century Calcutta eventually brought him a Nobel prize (although, as fictionalised by Ghosh, Ross is a much less heroic character than the one that official histories provide). *The Calcutta Chromosome's* action takes place in three temporal frames (the late 1890s, the mid-1990s and a very near future) and in locations that range from India to the Americas. Characters, places and events are connected by the mosquito, a vector that easily crosses boundaries between human and animal, rich and poor, here and there, and (with the parasite it transmits) also blurs the border between then and now.

Whereas *Time* and *Nature of Biology* occlude malaria's complex heterogeneity, Ghosh's novel dramatically foregrounds the ways in which outbreaks of malaria in particular places and times are manifestations of numerous complex interactions among parasites, mosquitoes, humans and various social, political (often military), administrative, economic, agricultural, ecological and technological processes. Although some of the interactions Ghosh depicts might be figments of his imagination, malaria's irreducible multiplicity is substantiated not only by malariologists (see Turnbull 2000, pp. 162-165) but also by scholars in other disciplines. For example, political historian Timothy Mitchell (2002) demonstrates that a terrible outbreak of malaria in Egypt during the 1940s cannot be understood as a predictable unitary event but as the effect of a series of complicated interconnections involving war, disease and agriculture:

> War in the Mediterranean diverted attention from an epidemic arriving from the south, brought by mosquitoes, that took advantage of wartime traffic. The insect also moved with the aid of the prewar irrigation projects and the ecological transformations those brought about. The irrigation works made water available for industrial crops, but left agriculture dependent upon artificial fertilizers. The ammonium nitrate used on the soil was diverted for the needs of war. Deprived of fertilizer, the fields produced less food, so the parasite carried by the mosquito found its human hosts malnourished and killed them at a rate of hundreds a day… The connections between a war, an epidemic and a famine depended upon connections between rivers, dams, fertilizers, [and] food webs… What seems remarkable is the way the properties of these various elements interacted. They were not just separate historical events affecting one another at the social level. The linkages among them were hydraulic, chemical, military, political, etiological, and mechanical (p. 27).

In the light of such examples, is it easy to see why sociologists of science such as David Turnbull (1989) see malaria as a political disease 'resulting from the dominance of the Third World by the colonial and mercantile interests of the West' (p. 287). Indeed, the development of tropical medicine as a specialisation within Western medical science can itself be understood as a response by colonial administrators to the devastating effects of malaria and other tropical diseases on imperial demands for resources and labour. For example, Latour (1988) quotes a French colonial official who complained in 1908: 'Fever and dysentery are the "generals" that defend hot countries against our incursions and prevent us from replacing the aborigines that we have to make use of' (p. 141).

Diane Nelson (2003) has recently drawn on Ghosh's novel – and other works in social and postcolonialist studies of science, technology and medicine – to explore Paul Rabinow's (1989) proposition that Europe's colonies were 'laboratories of modernity' (p. 289). Although Latour's (1987, 1988) work is an obvious and acknowledged influence on Nelson's analysis, the introduction to her essay evokes rhizomatic connectivity as much as actor-networks:

> Ghosh imagines the science of malaria, a disease dependent on multiple connections, enmeshed in the logics of a colonial counterscience. In turn, I argue that the hybrid form of social science fiction may be the most adequate way to think about the delirious products and unlikely networks of these colonial laboratories. Malaria as a disease figures largely there, an emblem of the simultaneously faithful and fickle nature of postcolonial connectivity (p. 246).

Similarly, I argue that deliberately seeking and/or making multiple, hybrid connections between the texts of science education, scientific media reports, social studies and histories of science, SF and SF criticism (as I have demonstrated here with respect to the assemblage of parasites, mosquitoes, humans, technologies and socio-technical relations that malaria signifies) enables generative lines of flight from the defined territories of Western science and science education. In South Africa the need for science educators and researchers to move beyond the arborescent knowledge space of Western laboratory science is given further urgency by the increasing complexity of the linkages between traditional cultural practices (such as the production of herbal medicines by traditional gatherers and healers) and the activities of transnational corporations (such as large pharmaceutical companies). In this respect the *Time* article points out that during the past few years research on treating drug-resistant malaria has demonstrated the efficacy of combining several compounds – the most powerful of which is artemisinin, a 2000-year old Chinese herbal remedy derived from *Artesmesia annua* (sweet wormwood) that cures 90% of patients in three days. This plant is

now being successfully cultivated in South Africa where some of the sources of traditional herbal malaria remedies have been over-harvested to near extinction. Given that around 80% of the black population in South Africa consult a traditional healer either before, after, or in preference to consulting a Western doctor, the interest of large pharmaceutical companies in traditional medicines is unsurprising, as is the potential for economic exploitation and environmental degradation (see, for example, Edwin C. Bbenkele, 1998). Europe's former colonies are still laboratories, not of colonialist modernity but of a neocolonialist postmodernity driven by the new imperialism of global corporate hypercapitalism. They are still laboratories for producing resources from Other people's labour in which the colonisers perform the experiments and the colonised are the guinea pigs. For example, as Sonia Shah (2002) reports, many non-Western countries have a thriving and largely unregulated industry in providing subjects for drug trials to multinational pharmaceutical companies.

I suggest that science education researchers in Europe's former colonies have a moral obligation to find the fissures in the arborescent and sedentary knowledge space of Western laboratory science and science education and begin to experiment with what Helen Verran (2001) calls 'postcolonial moments':

> Postcolonialism is not a break with colonialism, a history begun when a particular 'us,' who are not 'them,' suddenly coalesces as opposition to colonizer… Postcolonialism is the ambiguous struggling through and with colonial pasts in making different futures. All times and places nurture postcolonial moments. They emerge not only in those places invaded by European (and non-European) traders, soldiers, and administrators. Postcolonial moments grow too in those places from whence the invading hordes set off and to where the sometimes dangerous fruits of colonial enterprise return to roost (p. 38).

I have tried to demonstrate here that Deleuze and Guattari's (1987) figurations of rhizomatic thought and nomadic inquiry might nurture such postcolonial moments within the messy contexts of science education and research in regions such as southern Africa by disrupting and transgressing the epistemological and methodological colonialism (and even racism[12]) that results from the vast majority of epistemologies and methodologies currently legitimated in education having arisen almost exclusively from the social histories of the dominant Western cultures (and White races).

Losing *the* way: becoming nomadic in science education research

> History is always written from the sedentary point of view and in the name of a unitary State apparatus, at least a possible one, even when the topic is nomads. What is lacking is a Nomadology, the opposite of a history.
>
> …nomads have no history; they only have a geography.
>
> —Gilles Deleuze & Félix Guattari, *A Thousand Plateaus* (1987), pp. 23, 393.

Ronald Bogue (2004) argues that Deleuze and Guattari's binary opposition of nomadic and sedentary is a '*de jure* distinction of pure differences in nature', that is, the nomadic and the sedentary are 'pure tendencies that are real, yet that are experienced only in various mixed states. They are qualitatively different tendencies co-present across diverse social and cultural formations' (p. 173). Bogue adds:

> Deleuze and Guattari's nomadic thought is inherently unstable in that its use of binary oppositions is intended to be generative and mutative, but it is not therefore to be pursued in a haphazard and careless fashion… yet their effort is not to fix categories and

> demarcate permanent essences, but to make something pass *between* the terms of a binary opposition, and thereby to foster a thought that brings into existence something new. In this regard, the categories of pure differences in nature are themselves generative forces of differentiation, which through their mutual opposition function to displace and transform one another (p. 178; italics in original).

Western science and science education also tend to be written from a sedentary point of view and I have thus tried to demonstrate the generativity of performing a nomadic subjectivity. Like Rosi Braidotti (2002), I understand that 'the nomadic subject is a myth, or a political fiction, that allows me to think through and move across established categories and levels of experience' and that choosing to 'become nomad' is 'a move against the settled and conventional nature of theoretical and especially philosophical thinking' (n.p.). However, I emphasise that my disposition to 'wander' away from the conventional semiotic spaces of science education textbooks and scientific media reports, and to experiment with making passages to hitherto disconnected systems of signification, is neither 'haphazard' nor 'careless' but a deliberate effort to unsettle boundary distinctions and presuppositions.

John Zilcosky (2004) notes that some poststructuralist and postcolonialist theorists see merit not only in wandering but also in getting lost: 'losing one's way – literally and philosophically – leads to a deterritorialization of knowledge: literary wandering subverts… and resists the systematisation of the world' (p. 229). However, I agree with Zilcosky that such claims might be disingenuous, that 'lostness presupposes a state of being found' (p. 240). I prefer to imagine nomadic wandering in the discursive fields of science education research not as 'losing *one's* way' but as losing *the* way – as losing any sense that just one 'way' could ever be prefixed and privileged by the definite article. Like rhizomes, nomads have no desire to follow one path.

Notes

1. Law (1997) recognises the convergences between ANT and Deleuze and Guattari's approach to the 'naming of parts' (p. 2) of complex systems. Elsewhere (see Noel Gough, 2004c) I have coined the term 'rhizomANTic' to name a methodological disposition that connects rhizomatics with ANT and with Donna Haraway's (1991) feminist, socialist, materialist technoscience.
2. 'If we had known, if we only had known, we are shaking the tree'.
3. I realise that this formulation – 'modern *Western* science' rather than just 'science' or 'modern science' – introduces a problematic 'West versus the rest' dualism that might seem to overlook the historical influences of other cultures, such as Islam, India, and China, on its evolution. However, I also want to emphasise that I am referring to science as it was coproduced with industrialism in Europe during a particular historical period and to those of its cultural characteristics that have endured to dominate Western (and many non-Western) understandings of science as a result of Euro-American colonialism and imperialism.
4. This characterisation might appear to create a straw target but I firmly believe that it is defensible, For example, I have demonstrated elsewhere (Noel Gough, 1998a, 2003, 2004a) that a number of science and environmental educators who argue cogently (and I believe sincerely) for more multiculturalist approaches – including William Cobern (1996), Victor Mayer (2002), and David Yencken, John Fien and Helen Sykes (2000) – nevertheless reproduce monocultural (and even culturally imperialistic) representations of science through their use of rhetorical strategies that implicitly privilege Western science and take for granted its capacity to produce universal knowledge.
5. I therefore intend the word 'studies' to convey not only the conventional academic sense of pursuing some 'branch' of knowledge but also to suggest the various meanings of the noun 'study' in the arts, such as a sketch made as a preliminary experiment for a picture or part of it, or a musical composition designed to develop skill in a particular instrumental technique.
6. I recognise that 'marginalised knowledges' might be interpreted to be an arborescent concept but would argue that representing some knowledges as 'marginalised' or 'subjugated' serves a useful referential function within an arborescent sign system. As Claire Colebrook (2002) points out, Deleuze and Guattari use binary oppositions – such as the distinction between rhizome and tree – to create pluralisms: 'You begin

with the distinction between rhizomatic and arborescent only to see that all distinctions and hierarchies are active creations, which are in turn capable of further distinctions and articulations' (p. xxviii).

[7] This is not to say that science educators and science education researchers ignore the effects of the arts and popular media on public understandings of science but, rather, that their attention to the range and variety of these effects is somewhat limited. For example, Stephen Norris, Linda Phillips and Connie Korpan (2003) point out that although research on *reading* science media reports extends back at least four decades, science educators have only recently begun to recognise their value in teaching and assessing scientific literacy; these authors also draw attention to 'the relatively small corpus of work that has been completed in this area' (p. 124). As I have demonstrated elsewhere (Noel Gough, 1993b, 2001), many of the texts that purport to 'teach science fact through science fiction' (e.g., Rob DeSalle & David Lindley, 1997; Leroy W. Dubeck, Suzanne E. Moshier, & Judith E. Boss, 1988, 1994) portray popular media as sites of fantasy or of scientific 'misconceptions'. Thus, a common use of popular media in science education is to encourage students to identify these 'misconceptions'. For example, Dubeck et al (1988, 1994) devote two whole books to exposing 'pseudoscience' in more than fifty movies. More recently, in a special issue of *ENC Focus* on the theme of 'Becoming literate in mathematics and science', Frank Baker (2001) writes: 'Stereotypes and misconceptions are frequently generated by television and movie producers. Classroom teachers can take advantage of students' interest in popular movies to help them analyze the misconceptions' (n.p). Such readings constitute very narrow interpretations of popular media and implicitly devalue their educative potential by suggesting that their representations of science are in some way deficient unless they illustrate conventional textbook science 'correctly'. This obscures the ways in which particular works of art and popular media function as critical and creative probes of issues in science, technology and society that their creators and consumers see as problematic.

[8] As Donna Haraway (1989) explains, since the late 1960s the signifier SF has designated 'a complex emerging narrative field in which the boundaries between science fiction (conventionally, sf) and fantasy became highly permeable in confusing ways, commercially and linguistically'; thus, SF refers to 'an increasingly heterodox array of writing, reading, and marketing practices indicated by a proliferation of "sf" phrases: speculative fiction, science fiction, science fantasy, speculative futures, speculative fabulation' (p. 5). Electronic games and web-based media and activities have added to the complexity and heterodoxity of this array. In addition, many of the interrogations of technoscience produced by visual, installation and performance artists that once might have been localised in a small number of galleries or exhibition spaces now reach a much broader audience via the websites that almost invariably accompany such exhibitions. See, for example, *Gene(sis): Contemporary Art Explores Human Genomics* at www.gene-sis.net <12 September 2004>

[9] 'New Right biologism' (like social Darwinism before it) is the selective and strategic deployment of biological ideas in the pursuit of conservative political and economic goals. Thus, free-market economists privilege selected interpretations of chaos and complexity theories in order to 'naturalise' the desirability of global economic deregulation and oppose national development models that seek to internally regulate and articulate the agricultural and industrial sectors of a nation's economy. Instead of building national economies from networks of interlocking primary and secondary industrial assembly lines, post-Fordism promotes a global market in which efficiencies are achieved through, for example, farm concentration and specialisation.

[10] I have drawn particular attention to the significance for science education of contemporary cultural trajectories in popular media and global (eco)politics (see, e.g., Noel Gough, 1993a, 1998a, 2001, 2002, 2004b). See also the Study Guide for Science Education and Contemporary Culture (a unit in Deakin University's Master of Education program) at www.deakin.edu.au/education/units/ess712/ <30 January 2005>.

[11] As journals such as *Configurations* (published by Johns Hopkins University Press for the Society of Literature, Science, and the Arts) demonstrate, these are increasingly well-trodden paths.

[12] See James Scheurich and Michelle Young (1997) for a more detailed discussion of epistemological racism.

References

Appelbaum, Peter. (1995). *Popular Culture, Educational Discourse, and Mathematics*. Albany NY: State University of New York Press.

Appelbaum, Peter. (2000). Cyborg selves: Saturday morning magic and magical morality. In Toby Daspit & John A. Weaver (Eds.), *Popular Culture and Critical Pedagogy: Reading, Constructing, Connecting* (pp. 83-115). New York and London: Garland.

Appelbaum, Peter, & Clark, Stella. (2001). Science! Fun? A critical analysis of design/content/evaluation. *Journal of Curriculum Studies, 33*(5), 583-600.

Baker, Frank. (2001). Media literacy: yes, it fits in math and science classrooms. *ENC [Eisenhower National Clearinghouse for Mathematics and Science Education] Focus, 8*(3).

Bazerman, Charles. (1988). *Shaping Written Knowledge: The Genre and Activity of the Experimental Article in Science*. Madison: University of Wisconsin Press.

Bazerman, Charles. (1999). *The Languages of Edison's Light*. Cambridge, Mass.: MIT Press.

Bbenkele, Edwin C. (1998). *Enhancing economic development by fostering business linkages between the pharmaceutical companies and the traditional medicines sector*. Retrieved 17 January, 2005, from http://www.microfinancegateway.org/files/13974_Six_Studies_of_SMMEs_in_KwaZulu_Natal_and_Northern_Province_.htm#N_2_

Bogue, Ronald. (2004). Apology for nomadology. *Interventions: International Journal of Postcolonial Studies, 6*(2), 169–179.

Braidotti, Rosi. (2002). Difference, diversity and nomadic subjectivity. *Labrys. Études féministes*(1-2), n.p.

Cobern, William W. (1996). Constructivism and non-western science education research. *International Journal of Science Education, 18*(3), 295-310.

Colebrook, Claire. (2002). *Understanding Deleuze*. Crows Nest NSW: Allen & Unwin.

Collins, Harry, & Pinch, Trevor. (1998). *The Golem: What You Should Know about Science* (2nd ed.). Cambridge: Cambridge University Press.

Deleuze, Gilles. (1994). *Difference and Repetition* (Paul Patton, Trans.). New York: Columbia University Press.

Deleuze, Gilles, & Guattari, Félix. (1987). *A Thousand Plateaus: Capitalism and Schizophrenia* (Brian Massumi, Trans.). Minneapolis: University of Minnesota Press.

Deleuze, Gilles, & Guattari, Félix. (1994). *What is Philosophy?* (G. Burchell & H. Tomlinson, Trans.). London: Verso.

DeSalle, Rob, & Lindley, David. (1997). *The Science of Jurassic Park and the Lost World or, How to Build a Dinosaur*. London: HarperCollins.

Dubeck, Leroy W., Moshier, Suzanne E., & Boss, Judith E. (1988). *Science in Cinema: Teaching Science Fact Through Science Fiction Films*. New York: Teachers College Press.

Dubeck, Leroy W., Moshier, Suzanne E., & Boss, Judith E. (1994). *Fantastic Voyages: Learning Science Through Science Fiction Films*. Woodbury NY: AIP Press.

Dunwoody, Sharon. (1993). *Reconstructing Science for Public Consumption: Journalism as Science Education*. Geelong: Deakin University.

Eco, Umberto. (1984). *Postscript to The Name of the Rose* (William Weaver, Trans.). New York: Harcourt, Brace and Jovanovich.

Gabriel, Peter, & N'Dour, Youssou. (1989). Shaking the tree [Song]. London/Paris: Peter Gabriel Ltd/Editions Virgin Musique.

Ghosh, Amitav. (1997). *The Calcutta Chromosome: A Novel of Fevers, Delirium and Discovery*. New York: Avon Books.

Gorman, Christine. (2004, 26 July). Death by mosquito. *Time*.

Gough, Noel. (1993a). Environmental education, narrative complexity and postmodern science/fiction. *International Journal of Science Education, 15*(5), 607-625.

Gough, Noel. (1993b). *Laboratories in Fiction: Science Education and Popular Media*. Geelong: Deakin University.

Gough, Noel. (1998a). All around the world: science education, constructivism, and globalization. *Educational Policy, 12*(5), 507-524.

Gough, Noel. (1998b). 'If this were played upon a stage': school laboratory work as a theatre of representation. In Jerry Wellington (Ed.), *Practical Work in School Science: Which Way Now?* (pp. 69-89). London: Routledge.

Gough, Noel. (2001). Teaching in the *(Crash)* zone: manifesting cultural studies in science education. In John A. Weaver, Marla Morris & Peter Appelbaum (Eds.), *(Post) Modern Science (Education): Propositions and Alternative Paths* (pp. 249-273). New York: Peter Lang.

Gough, Noel. (2002). Thinking/acting locally/globally: Western science and environmental education in a global knowledge economy. *International Journal of Science Education, 24*(11), 1217-1237.

Gough, Noel. (2003). Thinking globally in environmental education: implications for internationalizing curriculum inquiry. In William F. Pinar (Ed.), *International Handbook of Curriculum Research* (pp. 53-72). Mahwah NJ: Lawrence Erlbaum Associates.

Gough, Noel. (2004a). Global science literacy [book review]. *Science Education, 88*(1), 146-148.

Gough, Noel. (2004b). Living in a material world. In William A. H. Scott & Stephen R. Gough (Eds.), *Key Issues in Sustainable Development and Learning: A Critical Review* (pp. 236-240). London and New York: RoutledgeFalmer.

Gough, Noel. (2004c). RhizomANTically becoming-cyborg: performing posthuman pedagogies. *Educational Philosophy and Theory, 36*(3), 253-265.

Haraway, Donna J. (1989). *Primate Visions: Gender, Race, and Nature in the World of Modern Science*. New York: Routledge.

Haraway, Donna J. (1991). A cyborg manifesto: science, technology, and socialist-feminism in the late twentieth century. In *Simians, Cyborgs, and Women: The Reinvention of Nature* (pp. 149-181). New York: Routledge.

Haraway, Donna J. (1994). A game of cat's cradle: science studies, feminist theory, cultural studies. *Configurations: A Journal of Literature, Science, and Technology, 2*(1), 59-71.

Harding, Sandra. (1986). *The Science Question in Feminism*. Ithaca NY: Cornell University Press.

Harding, Sandra. (1993). Introduction: Eurocentric scientific illiteracy – a challenge for the world community. In Sandra Harding (Ed.), *The 'Racial' Economy of Science: Toward a Democratic Future* (pp. 1-22). Bloomington and Indianapolis: Indiana University Press.

Harding, Sandra. (1994). Is science multicultural? Challenges, resources, opportunities, uncertainties. *Configurations: A Journal of Literature, Science, and Technology, 2*(2), 301-330.

Kinnear, Judith, & Martin, Marjory. (2000). *Nature of Biology Book 2* (2nd ed.). Milton, Queensland: John Wiley & Sons.

Latour, Bruno. (1987). *Science in Action: How to Follow Scientists and Engineers through Society* (Catherine Porter, Trans.). Milton Keynes: Open University Press.

Latour, Bruno. (1988). *The Pasteurization of France* (John Law Alan Sheridan, Trans.). Cambridge, Massachusetts: Harvard University Press.

Latour, Bruno. (1993). *We Have Never Been Modern* (Catherine Porter, Trans.). Cambridge, Massachusetts: Harvard University Press.

Latour, Bruno. (1999). *Pandora's Hope: Essays on the Reality of Science Studies* (Catherine Porter, Trans.). Cambridge, Massachusetts: Harvard University Press.

Latour, Bruno, & Woolgar, Steve. (1979). *Laboratory Life: The Social Construction of Scientific Facts*. Beverly Hills: Sage Publications.

Law, John. (1997). *Topology and the naming of complexity*. Retrieved 17 January, 2005, from http://www.comp.lancs.ac.uk/sociology/papers/Law-Topology-and-Complexity.pdf

Law, John. (2003). *Making a mess with method*. Retrieved 25 January, 2005, from http://www.comp.lancs.ac.uk/sociology/papers/Law-Making-a-Mess-with-Method.pdf

Law, John. (2004). *After Method: Mess in Social Science Research*. London: Routledge.

Lemke, Jay L. (1990). *Talking Science: Language, Learning, and Values*. Norwood NJ: Ablex Publishing Corporation.

Lemke, Jay L. (1992). *The missing context in science education: science.* Paper presented at the Annual Meeting of the American Educational Research Association, Atlanta, GA.

Lemke, Jay L. (2001). Articulating communities: sociocultural perspectives on science education. *Journal of Research in Science Teaching, 38*(3), 296-316.

Mayer, Victor J. (Ed.). (2002). *Global Science Literacy*. Dordrecht: Kluwer.

Mitchell, Timothy. (2002). *The Rule of Experts: Egypt, Techno-Politics, Modernity*. Berkeley CA: University of California Press.

Nelson, Diane. (2003). A social science fiction of fevers, delirium, and discovery: *The Calcutta Chromosome*, the colonial laboratory, and the postcolonial new human. *Science Fiction Studies, 30*(2), 246-266.

Norris, Stephen P., & Phillips, Linda M. (1994). Interpreting pragmatic meaning when reading popular reports of science. *Journal of Research in Science Teaching, 31*(9), 947–967.

Norris, Stephen P., Phillips, Linda M., & Korpan, Connie A. (2003). University students' interpretation of media reports of science and its relationship to background knowledge, interest, and reading difficulty. *Public Understanding of Science, 12*(2), 123–145.

O'Riley, Patricia A. (2003). *Technology, Culture, and Socioeconomics: A Rhizoanalysis of Educational Discourses*. New York: Peter Lang.

Peters, Michael. (2004). Geophilosophy, education and the pedagogy of the concept. *Educational Philosophy and Theory, 36*(3), 217-231.

Porush, David. (1991). Prigogine, chaos and contemporary SF. *Science Fiction Studies, 18*(3), 367-386.

Rabinow, Paul. (1989). *French Modern: Norms and Forms of the Social Environment*. Chicago: University of Chicago Press.

Richardson, Laurel. (2001). Getting personal: writing-stories. *International Journal of Qualitative Studies in Education, 14*(1), 33-38.

Rorty, Richard. (1979). *Philosophy and the Mirror of Nature*. Princeton NJ: Princeton University Press.

Ross, Andrew. (1996). Earth to Gore, Earth to Gore. In Stanley Aronowitz, Barbara Martinsons, Michael Menser & Jennifer Rich (Eds.), *Technoscience and Cyberculture* (pp. 111-121). New York and London: Routledge.

Rouse, Joseph. (1993). What are cultural studies of scientific knowledge? *Configurations: A Journal of Literature, Science, and Technology, 1*(1), 1-22.

Roy, Kaustuv. (2003). *Teachers in Nomadic Spaces: Deleuze and Curriculum*. New York: Peter Lang.

Scheurich, James Joseph, & Young, Michelle D. (1997). Coloring epistemologies: are our research epistemologies racially biased? *Educational Researcher, 26*(4), 4-16.

Shah, Sonia. (2002, 1 July). Globalizing clinical research: Big Pharma tries out First World drugs on unsuspecting Third World patients. *The Nation, 275,* 23-28.

Shapin, Steven. (1994). *A Social History of Truth: Civility and Science in 17th Century England*. Chicago: University of Chicago Press.

Turnbull, David. (2000). *Masons, Tricksters and Cartographers: Comparative Studies in the Sociology of Scientific and Indigenous Knowledge*. Amsterdam: Harwood Academic Publishers.

Verran, Helen. (2001). *Science and an African Logic*. Chicago and London: University of Chicago Press.

Weaver, John A. (1999). Synthetically growing a post-human curriculum: Noel Gough's curriculum as a popular cultural text. *Journal of Curriculum Theorizing, 15*(4), 161-169.

Weinstein, Matthew. (1998a). Playing the paramecium: science education from the stance of the cultural studies of science. *Educational Policy, 12*(5), 484-506.

Weinstein, Matthew. (1998b). *Robot World: Education, Popular Culture, and Science*. New York: Peter Lang.

Weinstein, Matthew. (2001a). Guinea pig pedagogy: critiquing and re-embodying science/education from other standpoints. In Angela Calabrese Barton & Margery D. Osborne (Eds.), *Teaching Science in Diverse Settings: Marginalized Discourses and Classroom Practice* (pp. 229-250).

Weinstein, Matthew. (2001b). A public culture for guinea pigs: US human research subjects after the Tuskegee Study. *Science as Culture, 10*(2), 195-223.

Woolgar, Steve. (1988). *Science: The Very Idea*. London: Tavistock.

Yencken, David, Fien, John, & Sykes, Helen (Eds.). (2000). *Environment, Education and Society in the Asia-Pacific: Local Traditions and Global Discourses*. London and New York: Routledge.

Zilcosky, John. (2004). The writer as nomad? The art of getting lost. *Interventions: International Journal of Postcolonial Studies, 6*(2), 229–241.