

## Playing within/against entombed scholarship: episodes in an academic life

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### Prologue

This essay recounts two episodes in my career as an academic science educator, one from near its beginning and another from near its end. In the spirit of Laurel Richardson's (1997b) reflections on writing *Fields of Play: Constructing an Academic Life* (Laurel Richardson, 1997a), I have written them as stories of my "struggles in academia in the context of contemporary intellectual debates about entrenched authority, disciplinary boundaries, writing genres, and the ethics and politics of social scientific inquiry and presentation" (p.1). Like Richardson, I hope that these stories might resonate with readers who similarly struggle to make sense of their academic lives.

The first episode is an almost verbatim restatement of the Introduction to *Laboratories in Fiction: Science Education and Popular Media* (Noel Gough, 1993), a research monograph commissioned by Deakin University as a resource for a new distance education subject, Educational Issues in Science and Technology (I write "almost verbatim" because I have lightly edited my 1993 text to remove some textual infelicities and to remind readers of its temporal location in the early 1990s rather than the present).

I describe elsewhere (Noel Gough, 2015) how *Laboratories in Fiction* fits into my life history, and John Weaver's (1999) essay review offers a generous appraisal of its significance for science educators and curriculum theorists, but the monograph itself is long out of print. In retrospect, the Introduction foreshadows my disposition to perform educational inquiries as narrative experiments catalyzed by intertextual readings of selected fictions drawn from popular media genres. As I increasingly acknowledged the influence of Gilles Deleuze and Félix Guattari's concepts (especially *rhizome*, *nomad* and *lines of flight*) in shaping these experiments I characterized them as examples of *rhizosemiotical play* (Noel Gough, 2007a, 2007b). Issues in science education that I explore in these experiments include representations of particular subject matters in textbooks and news media (Noel Gough, 2004, 2006) and connections between thought experiments in the sciences (and other disciplines) and their performance in educational inquiry (Noel Gough, 2010). As I recount elsewhere (Noel Gough, 2015), *currere* – William Pinar's (1975) autobiographical method of curriculum inquiry – became a significant component of my teaching and research repertoires from the late 1970s onwards, but I did not *perform* autobiographical curriculum inquiry (as distinct from using it in my teaching of curriculum studies) until much later (Noel Gough, 1991).

The second episode is little more than a rant – and an invitation to colleagues – arising from recent attempts to specify a curriculum for biopolitical critical literacy in science teacher education (Noel Gough, in press). In this episode I mobilize the zombie imaginary to identify dead ideas that "walk" among contemporary science educators and invite readers to ask: how can we resist them?

### Episode 1 (1993): Introducing *Laboratories in Fiction*

I am not conscious of studying anything called "science" in primary school ("nature study" was as close as we got). My induction into Science (with a capital S) as a discrete subject/object of study began in secondary school during the late 1950s, a period in which it was easy to be

optimistic about science and technology. I have vivid memories of the 1957-58 International Geophysical Year (IGY), many of them associated with atmospheric physics research conducted by Australian scientists in Antarctica. Intense sunspot activity during the IGY produced conditions that made the aurora australis visible from southern Australia. I recall warm summer nights on the beach near my home in South Melbourne watching luminous streamers radiating above the horizon and my thoughts often drifted to imagining the life of an Antarctic scientist, and envisioning myself in that role. But my heroic visions of this life were drawn less from science textbooks or journalism than from novels such as Ivan Southall's (1956) *Simon Black in the Antarctic*, one of a series of his books for young people featuring the eponymous Simon Black, a brilliant aerospace inventor, engineer, pilot and United Nations special agent whose adventures took him to exotic locations (including Mars and Venus). Simon Black was one among several imaginary people who contributed a great deal to my scientific optimism (see Gough 1991). In 1957 I watched Sputnik 1 orbiting the earth, delighted to see – *at last!* – the tangible evidence of humankind's entry into the space age (I was, of course, oblivious to its Cold War implications). Looking back at the late 1950s, Donald Fagen (1982) captures the buoyant mood of many young people in his song, "IGY (International Geophysical Year)":

*Get your ticket to that wheel in space  
While there's time...  
You'll be a witness to that game of chance in the sky  
The fix is in  
You know we've got to win  
Here at home we'll play in the city  
Powered by the sun  
Perfect weather for a streamlined world  
There'll be spandex jackets one for everyone*

*... A just machine to make big decisions  
Programmed by fellows with compassion and vision  
We'll be clean when their work is done  
We'll be eternally free yes and eternally young  
What a beautiful world this'll be  
What a glorious time to be free*

At high school, then throughout my undergraduate studies in science and education, and again during my years as a teacher of high school science and biology, my enthusiasm for science never waned, although I became more cynical about the "compassion and vision" of those who orchestrated the "big decisions." But in 1972 I became a science teacher educator and began to reflect critically on the assumptions underlying my enthusiasm. Given the length of time I have now worked in academia, and to pre-empt any tendencies toward self-satisfaction or complacency in this account, I cannot resist quoting Leonard Cohen (1988):

*They sentenced me to twenty years of boredom  
For trying to change the system from within  
I'm coming now I'm coming to reward them  
First we take Manhattan, then we take Berlin*

*Laboratories in Fiction* is an example of “trying to change the system from within” and also illustrates one of the ways in which I have tried to escape “boredom.” In the spirit of Cohen’s lyrics, I interpret “coming to reward them” as dedicating this monograph to the now absent presences of my high school and university science teachers: it could only have been written without them.

Two other verses of Cohen’s song are more directly pertinent to the content of this monograph:

*I’m guided by a signal from the heavens  
I’m guided by this birthmark on my skin  
I’m guided by the beauty of our weapons  
First we take Manhattan, then we take Berlin...*

*I don’t like your fashion business, mister  
I don’t like these drugs that keep you thin  
I don’t like what happened to my sister  
First we take Manhattan, then we take Berlin*

In these highly compressed images, Cohen captures many of the confusions and contradictions of the late 20<sup>th</sup> Century world and the ambiguous roles of science and technology in shaping it. The ironies that are mere whispers in Fagen’s evocation of the mood of the late 1950s (“The fix is in...we’ve got to win”) are an ominous presence in the late 1980s. Anticipating a “wheel in space” – like the space station that serenely orbits the Earth in visual harmony with Johann Strauss’s “Blue Danube” in Stanley Kubrick’s (1968) *2001: A Space Odyssey* – is a very different “signal from the heavens” from those anticipated by the Strategic Defense Initiative (SDI) announced by US President Ronald Reagan in 1983. The mainstream media used the nick-name “Star Wars” for the SDI – a deceptive move that cloaked the SDI in the epic grandeur of George Lucas’s (1977) cinematic saga. But contemplating “the beauty of... weapons” in a mythic realm (*Star Wars* was set “a long time ago in a galaxy far away”) is a very different matter from romanticizing them in the world *we* inhabit (at the time of writing *Laboratories in Fiction*, the SDI was intended to be here, now).

Similarly, the world that Fagen suggests that we once anticipated – affluent (“spandex jackets... for everyone”), hygienic (“we’ll be clean”) and healthy (“we’ll be... eternally young”) – did not emerge from the work of “fellows with compassion and vision.” Instead, as Cohen insinuates, science and technology added to the power of capitalist and patriarchal interests to exploit and oppress people, especially women, through the global fashion industry, multinational drug corporations and experimentation in reproductive technologies. Cohen sings “I don’t like what happened to my sister” and I don’t like that either, which is why we need to “take” Manhattan and Berlin – to capture and critically mobilize the cultural resources represented by these emblematic sites of Western society. Apart from their centrality in the art and commerce of their respective continents, Manhattan and Berlin are culturally connected in other ways; for example, the development of the USA’s atomic bomb (aka The Manhattan Project) was a precursor to the Eastern bloc erecting the Berlin wall and maintaining it for nearly two decades as a symbol and materialization of the Cold War.

I interpret “First we take Manhattan” as a series of snapshots sampling cultural manifestations of postmodernity. Katherine Hayles (1990) characterizes “cultural postmodernism” as the “convoluted ambiguity” that accompanies “the realization that what has

always been thought of as the essential, unvarying components of human experience are not natural facts of life but social constructions,” (p. 265) an ambiguity revealed in the diverse – and not necessarily welcome – products of science and technology (“the beauty of our weapons,” “the drugs that keep you thin”) and the power arrangements that mediate their uses. Technologically sophisticated weapons and drugs, and the global marketplace controlling them, have reconstructed our “natural” senses of beauty and health in complex and contradictory ways.

Juxtaposing “IGY” with “First we take Manhattan” raises, through the medium of popular song, a number of problems and issues concerned with the convoluted interrelationships of science, technology and society. Similar problems and issues have been addressed in recent years from a variety of academic perspectives, with critical feminist scholars providing some of the most cogent and trenchant critiques. For example, Ruth Bleier (1986) writes:

Science is an integral part, expression, and product of a culture’s complex set of ideologies, and it has ideological commitments to certain social beliefs, values, and goals. These commitments are, on the one hand, a source of its great strength and value and, on the other, the source of its oppressive power... It was, after all, in response to our society’s social beliefs, values, and urgent needs that scientists, for example, worked to develop antibiotics before and during the Second World War, at the same time that other scientists worked to develop the atom bomb, a weapon designed not to save lives by bringing a quick end to the war with Japan but to announce the ultimate phallic power and hegemony of United States capitalism in the leadership of the coming war against the Soviet Union (p. 57).

Like Cohen, Bleier uses images of medicine and weapons to invoke some of the dilemmas we face in trying to understand science and transform the terrifying power that it represents. That is, “IGY” and “First we take Manhattan” can be interpreted as texts that complement Bleier’s essay – different but congruent expressions of the hopes and fears aroused by the promises and threats of scientific “progress.”

You do not have to agree with my idiosyncratic interpretation of “First we take Manhattan” to acknowledge that it generates meanings appropriate to studies of science and technology. Popular art is full of malleable allusions that can be retrofitted to the consumer’s consciousness. Some people see popular media as ephemeral and/or disposable. But, like art in any medium, popular artifacts – songlines, snippets of melody, archetypal images, pithy lines of dialogue, characters in movies, TV shows, novels, plays and comic strips – readily work themselves into our individual and collective memories and mythologies. As J.G. Ballard (quoted in V. Vale & Andreas Juno, 1984) observes, “pop artists deal with the lowly trivia of possessions and equipment that the present generation is lugging along with it on its safari into the future”(p. 155). I did not quote “First we take Manhattan” simply because the lyrics speak to me of issues in science and technology studies, but also because Cohen’s songs are among the “lowly trivia of possessions” that I have been “lugging along... into the future” since 1966. They continue to be part of the conceptual “equipment” that connects me with the world and helps me to make sense of it.

*Laboratories in Fiction* is about making connections – connections between science and popular media that enrich science education and respect popular art and artists. Consider, for example, the following excerpt from Janette Turner Hospital’s (1988) novel, *Charades*:

“Question,” Charade says. “If a woman stands in the middle of Massachusetts Avenue facing MIT, but her memory is so vividly snagged on one particular day of her childhood in

the village of Le Raincy that she is unaware... that she is *oblivious* to the cars around her and so she is hit, run over, killed... Is she more truly in Boston or France when she dies?"

"Well put," Koenig says. "The indeterminacy problem in a nutshell." (p. 191)

This passage does several things. Firstly, it illustrates one of the ways in which meanings emerge, unforced, in the course of everyday conversation. Charade and Koenig are not involved in a didactic exchange in which one is trying to transmit to the other a stipulative definition of quantum indeterminacy as postulated by Werner Heisenberg and Neils Bohr – they are just having a chat. Secondly, given that Charade's question is itself a response to something that Koenig has said previously (the details of which are unimportant), both Charade and Koenig are modeling a strategy for good teaching that Garth Boomer (1982) terms "connecting":

The teacher is a senior reader of the school culture and special senior reader of the specialist subculture of the subject. Wittingly or unwittingly, he/she is demonstrating how to be a reader and maker of meaning... The more richly the teacher can spin a tapestry of metaphor and analogy into a "thick" redundant text of thinking about something new, the more likely it is that students will find a way in. If students are encouraged to spin out reciprocally their own webs of anecdote, metaphor and analogy, it is less likely that some will remain outside the next text. The art of generating apt analogy and metaphor is central to the "reading" teacher's task (pp. 119-120).

Charade and Koenig are "reading" each other's speech acts and responding by spinning reciprocally "their own webs of anecdote, metaphor and analogy." Their conversation also exemplifies a point of entry into a subject matter of science that is different from that used by most science teachers. *Charades* is a popular novel that incorporates ideas drawn from quantum mechanics, field theories and other aspects of subatomic physics. In part this is because one of the main characters is a research physicist but it is also because the author is playing creatively with the existential and metaphysical implications of quantum theory. *Charades* is not only more pleasurable to read than most physics textbooks – I agree with the reviewer quoted on the novel's back cover that it is "an example of that old-fashioned, almost extinct phenomenon, the novel you can't put down" – but it also situates meanings drawn from the subatomic world of quantum physics within the politics of everyday human activity and experience. It is also worth noting that the majority of contemporary school science textbooks ignore the physics explored in *Charades*. Although the "new physics" has been with us since the late 19<sup>th</sup> Century, few late 20<sup>th</sup> Century school science textbooks pay more than lip-service to its existence, let alone explore its implications for understanding what another popular novelist (Douglas Adams, 1982) calls "life, the universe and everything."

Neither *Charades* nor "First we take Manhattan" are isolated examples. I could have made similar points using novels such as Tom Robbins' (1990) *Skinny Legs and All* or Lewis Shiner's (1988) *Deserted Cities of the Heart* and songs such as Paul Simon's (1986) "The boy in the bubble" or Sting's (1985) "We work the black seam." *Laboratories in Fiction* demonstrates that popular media – music, movies, comics, novels, and other media that are popular with children and young adults – are rich and meaningful sources of information, images and insights concerning science, technology and society and their interrelationships. I also argue that popular media are much more than "icing on the cake," a way of illustrating the subject matters of science in a way that is entertaining and "relevant" to young people. Rather, popular media provide *sites for inquiries* into the meanings of scientific concepts and methods and provide some of the

“equipment” (as Ballard puts it) for investigating problems and issues of science, technology and society.

I thus affirm for science education a position adopted already by many teachers in subjects such as English language and literature, media studies and social education, namely, that popular media are “texts” in their own right and that they merit close “reading” by both teachers and learners – who should also be encouraged to respond to them critically and creatively. I chose the title, *Laboratories in Fiction*, with the deliberate intention of emphasizing and exemplifying two key propositions:

- “Laboratories” – in their various roles as sites, symbols, emblems and metaphors of scientific labor – are represented in numerous and diverse ways in popular media, and these images of science should be significant foci of science education.
- Many examples of popular media are “laboratories of ideas” in which *meanings* are subjected to experimentation.

At this point, I should clarify my use of the term “popular.” By *popular* media I mean media produced with the deliberate intention of having wide appeal, especially (but not exclusively) among young people. It is not necessary for a work to *achieve* wide appeal to be designated “popular” – a pop song is still a pop song even if it doesn’t make it into the *Billboard* Hot 100. I also focus chiefly on works of “art” (such as songs) and/or “fiction” (such as comics, novels, movies) rather than what might be distinguished as *science journalism* – although magazines like *New Scientist* and many television documentaries are quite clearly intended to be “popular.”

Marshall McLuhan (1960) argues persuasively for teaching and learning *with* the texts and artifacts of mass media and popular culture:

It’s misleading to suppose there’s any basic difference between education and entertainment. This distinction merely relieves people of the responsibility of looking into the matter. It’s like setting up a distinction between didactic and lyric poetry on the grounds that one teaches, the other pleases. However, it’s always been true that whatever pleases teaches more effectively. Where student interest is already focused is the natural point at which to be in the elucidation of other problems and interests. The educational task is not only to provide basic tools of perception but also to develop judgment and discrimination with ordinary social experience... To be articulate and discriminating about ordinary affairs and information is the mark of an educated [person] (p. 3).

The idea that learning should begin “where student interest is already focused” has long been something of a cliché among progressive educators, but its sentiments might have been honored more in their rhetoric than in young people’s lived experience. If teachers are to develop “judgment and discrimination with ordinary social experience,” they cannot merely *begin* “where student interest is already focused” and then retreat to the relative security of their own interests and experience. Garth Boomer’s (1982) notion of teaching as a kind of “bushcraft” is pertinent:

In the ecology of the school “bush” there is a bewildering array of texts, tests, assignments and artefacts. The teacher should be used to finding interesting and pertinent specimens and talking about their characteristics, habits and habitats. Students should be encouraged to familiarize themselves with funny creatures like science textbooks, learning how to tame

them, remembering where dangers lurk... Teachers should not drive students in a tourist bus through the school curriculum, encouraging the bland recital of tourist blurbs. Students should be obliged to savour the texture of life, wild and rich (p. 119).

Although I agree wholeheartedly with Boomer in most respects (*Laboratories in Fiction* is in many ways a field guide to the “dangers” lurking in “funny creatures like science textbooks”), I recommend some role reversals in his recommendations. Teachers should also be “obliged to savour” the wild and rich textures of their students’ lives. I see great merit in J.G. Ballard’s (1985) interpretation of the ways we and our students experience our worlds:

The most prudent and effective method of dealing with the world around us is to assume that it is a complete fiction... We live in a world ruled by fictions of every kind – mass-merchandizing, advertising, politics conducted as a branch of advertising, the instant translation of science and technology into popular imagery, the increasing blurring and intermingling of identities within the realm of consumer goods... We live inside an enormous novel (p. 8).

I understand the term “fiction,” in the sense in which it derives from the Latin *fictio*, as something fashioned by a human agent, and thus interpret Ballard’s reference to living “inside an enormous novel” as one figuration of living “in a world ruled by fictions of every kind.” Although I agree that many of us live inside enormous novels (the plural is important), our subjectivities – and certainly those of many young people – also reside (at least partially) in the enormous fictions produced by multi-media franchises that market videos, movies, computer games and other merchandise. If teachers cannot engage empathetically and constructively with these fictional worlds, many young people will leave the compulsory years of schooling with feelings similar to those expressed by Bruce Springsteen (1984):

*We busted out of class  
We had to get away from those fools  
We learned more from a three-minute record  
Than we ever learned in school...*

## Interlude

During the quarter century that has elapsed since I began writing *Laboratories in Fiction*, there have been both continuities and changes in the objects of my inquiries and the research methodologies I have privileged. I have continued to focus on science education and environmental education, but internationalization, globalization and transnational curriculum inquiry have become increasingly salient research interests. My continuing disposition to deploy methodologies informed by narrative and poststructuralist/deconstructive theorizing, has been refined by reference to posthumanism (Gough, 2015) and what I now prefer to call a *postparadigmatic* position (Noel Gough, 2016). The idea of *complexity* – a heterogeneous assemblage of concepts and metaphors arising from studies of complex systems in a variety of scholarly disciplines – also informs much of my recent research (Noel Gough, 2012, 2013), with particular reference to the politics of complexity reduction. Also, I now try to write in the spirit of Deleuze’s (1995) encouragement for “writing to bring something to life, to free life from where

it's trapped, to trace lines of flight" (pp. 140-1). In what follows, I want to free science educators from the traps of dead ideas and encourage others to do likewise.

## **Episode 2 (2017): Dead ideas that walk among science educators; an incomplete list**

Lyn Carter's (2014) essay on science education, neoliberalism and resistance links Foucault's lectures on biopolitics in the late 1970s with the Occupy Wall Street protests that began during September 2011 in New York City. Carter invokes Deleuze and Guattari's familiar figuration of the rhizome to assert that it is "difficult to come to grips with...Occupy":

There is so much one could interrogate – from the protester demographics of the mainly highly-educated young White males and the concomitant elision and erasure of the racialised nature of inequality, to the information-age protest style with its own generator, YouTube™ videos, tweets, blog posts and help from hacktivist group *Anonymous* (p. 30).

One characteristic of the Occupy Wall Street movement that Carter overlooks is that many of the protesters coupled their political discontent with a specific aesthetic figuration by dressing as zombies (Daily Mail Reporter, 2011). A number of cultural and political commentaries describe neoliberal economics by reference to the zombie imaginary, including John Quiggin's (2010) *Zombie Economics: How Dead Ideas Still Walk Among Us*, David McNally's (2011) *Monsters of the Market: Zombies, Vampires and Global Capitalism*, and Chris Harman's (2012) *Zombie Capitalism: Global Crisis and the Relevance of Marx*.

I borrow from Quiggin's title to ask: how *do* dead ideas still walk among science educators? I will begin a list of such dead ideas and invite readers/colleagues to add to it (I would be delighted if someone volunteered to start a blog to which anyone interested could contribute). My list will be very short because I am reaching (or have already reached) my word limit for this chapter.

### ***Dead idea #1: School science laboratories***

Do a Google™ search for "school science laboratories" and go to the "Images" tab. There you will find page after page of images that demonstrate the materialization of a dead idea. Most school laboratories are stereotypical gestures towards the diverse sites in which contemporary scientists work. They are equipped with apparatus associated with the image of a scientist described by Margaret Mead and Rhoda Metraux (1957) as "a man who wears a white coat... surrounded by... test tubes, bunsen burners, flasks and bottles" (p. 386). The activities that take place in such classrooms – indeed, the activities that *can* take place in them – bear little or no resemblance to contemporary scientific practice. For many years, the physical sciences in particular have been characterized by the types of highly industrialized and technologized "Big Science" that require very different facilities from those on which school laboratories are modeled. Many scientific specializations – mathematical, physical, biological, cosmological, etc. – have moved away from studying the simple systems that were the objects of mainstream science from Newton's day to the late 19<sup>th</sup> Century towards studies of complex systems (see, e.g., Jack Cohen & Ian Stewart, 1994). Whether they are furnished with optical or electron microscopes, bunsen burners, centrifuges or cyclotrons, most laboratories are equipped for studying the *material* structures of simple systems. But in the study of complex systems – protein folding in cell nuclei, task switching in ant and bacteria colonies, the nonlinear dynamics of the earth's atmosphere, far-from-equilibrium chemical reactions – the emphasis is on modeling their

*informational* structure through computer simulations (see, e.g., John L. Casti, 1997). Little of what now counts as “progress” among communities of working scientists is accomplished by the individualistic, small-scale, low-tech “bench work” for which school laboratories are designed.

Why do we persist? How can we resist?

### ***Dead idea #2: The “balance” of nature***

Recent research by Jennifer Nicholls and Robert Stephenson (2015) examines teachers’ personal and professional beliefs about climate change and climate change education. They analyzed survey data from over 300 Queensland (Australia) primary and secondary teachers to identify teachers’ understandings and beliefs relating to the realities, causes, and consequences of climate change, and to illuminate how teachers conceptualize climate change education in terms of content and processes. Teachers were asked to express in their own words what climate change education involves. The dominant theme that emerged from their responses was:

#### *Balance or Both Sides of the Climate Change “Debate”*

The idea of “balance” and presenting students with “both sides of the climate change argument” or a balanced perspective was most frequently identified by teachers as important in climate change education. Teachers identified that there existed a “for and against” argument or more than one side to climate change that students should be made aware of. Not telling students what to believe but allowing them to review or be given all “sides” of the argument so they were able to “make up their own mind” about climate change was also considered important by teachers (p. 25).

In the light of poststructuralist understandings of subjectivity and agency, I interpret these teachers’ standpoint as evidence of the constitutive force of a discourse of dead ideas centred on deeply sedimented conceptions of “natural” order – order as stability, predictability, and equilibrium. Such conceptions of “natural” order are pervasive in many disciplines, but I speculate that they can be attributed in large part to a “success” of conventional science (mis)education, namely, what we can quite literally call the “textbook ecology” received by many undergraduates in US colleges and universities for more than 50 years.

During the post-World War II period, under the leadership of Eugene Odum, the US version of systems ecology privileged the concept of the ecosystem as a stable and enduring emblem of “natural” order, epitomised by the dominance of the “balance of nature” metaphor which, as Kim Cuddington (2001) argues, “is shorthand for a paradigmatic view of nature as a beneficent force” (p. 463). Environmental historian Donald Worster (1995) argues that Odum’s (1953) textbook, *Fundamentals of Ecology*, “laid so much stress on natural order that it came close to dehistoricizing nature altogether” (p. 70). He also notes that during the 1970s and 1980s “the field of ecology... demolished Eugene Odum’s portrayal of a world of ecosystems tending towards equilibrium” (p. 72). Worster cites numerous studies that deliver the consistent message that the very concept of the ecosystem has receded in usefulness and, to the extent that the word “ecosystem” remains in use, that it has lost its former implications of order and equilibrium. Similarly, Andrew Jamison (1993) points out that systems ecology contributed very little to the solution of environmental problems and, by the late 1970s, new evolutionary approaches had become increasingly popular among ecologists, “so that systems ecology today is only one (and not even the most significant one at that) of a number of competing ecological paradigms” (p. 202). Nevertheless, Odum’s ideas have persisted as the lumbering zombies of conceptual change in ecology, a particularly appropriate metaphor given the publication of a fifth edition of

*Fundamentals of Ecology* (Eugene P. Odum & Gary W. Barrett, 2005) three years after his death. The second edition (coauthored with Howard T. Odum) was published in 1959 and a third edition (sole-authored) in 1971. According to Odum's biographer, Betty Jean Craige (2001), his textbook, *Basic Ecology* (1983), "was actually the fourth edition of *Fundamentals of Ecology*" (p. 191).

Gregory Cooper (2001) observes that in areas such as population and community ecology, "the balance of nature idea ... has worked in the background, shaping inquiry" (p. 482), but that it has been argued largely on conceptual rather than empirical grounds. In this light, it is significant that Robert Ulanowicz's (1997, 2009) empirical work – which includes network analysis of trophic exchanges in ecosystems, the thermodynamics of living systems, causality in living systems, and modelling subtropical wetland ecosystems – emphasises that chance, disarray and randomness are necessary conditions for creative advance, emergence and autonomy in the natural world.

It is more than a little ironic that the persistence of a dead idea in the science of ecology provides science teachers with an excuse for abrogating their professional responsibility to teach the scientific evidence for anthropogenic climate change.

## Epilogue

I share Susanne Kappeler's (1986) antipathy to the conventional ways of concluding an academic essay: "I do not really wish to conclude and sum up, rounding off the argument so as to dump it in a nutshell on the reader. A lot more could be said about any of the topics I have touched upon" (p. 212)

All I wish to "dump... on the reader" is a heartfelt request to identify, question, critique and resist the "entombed scholarship" that continues to deaden science education by being alert to, and deploying, the variety of cultural and academic resources to which they and their students have access, which I hope I have exemplified in the two episodes recounted above. I encourage you to add to, and to advertise, the list of dead ideas that walk among science educators I have commenced here.

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