Extinction and Overspecialization: The Dark Side of Human Innovation

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Science and technology are among the principal characteristics of the human adaptive trait we call *innovation*. Our goal in this report is to provide the logic and justification for reconceptualizing innovation as a case of too much specialization rather than "general-purpose" adaptation. General-purpose/domain-general traits are assumed by many to be preferentially selected-for because they offer a species the flexibility to switch between available solutions when environmental challenges occur. Traditionally, technology falls under the guise of domain-general traits manifest in culturally universal ways, yet in view of its impact on the environment we argue it meets the criteria for overspecialization. Specialization is evolution's answer to fine-tuning a species to its niche, but it comes with a high risk should the narrowly defined niche change in substantive ways. Without flexibility, the lag time needed to adapt through random mutations is too long and collapse follows. The authors briefly cover the three basic classes of extinction, and then present three assertions why human innovation should be reconceptualized as too much specialization. This position turns on the notion that technology, consumption patterns, and overpopulation together are beginning to compromise the integrity of the global ecosystem. The natural history of technology reveals a monotonic function suggesting that humans have never voluntarily given up their investments in technology. While *some* new technologies are being designed with the hope of reducing environmental impacts, there is no hard evidence to suggest that enough can be done to reduce the demand side, nor help to reduce the population growth rate before the global ecosystem is compromised. If the present culture of technology endangers the environment much longer, there may be too few alternatives than nature's punishment for monopoly.

Key Words: Innovation; Evolution; Technology; Extinction; Specialization, Adaptation.

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The idea that our species is able to survive because it has the most highly evolved and natural form of innovation ever seen has become virtually axiomatic; that is, almost no one bothers to question it anymore. Humans not only survive, they prosper owing to their ability to modify their surroundings. We do this for the ultimate purpose of optimizing the reproduction of mankind. Statistics of past population growth and the United Nations projections testify to that fecundity (2006). Science and technology are the backbone of that growth. They are the physical realizations of our naturally selected-for trait to innovate (Diamond, 1997). The act of innovating, inventing, and improving tools is what big brains are best at doing (Pratarelli, 2003); that is our principal adaptive trait, and we amplify its effects using culture. In time it reshapes the niche, but the assumption that it does so in a *positive way* is entirely anthropocentric and arbitrary.

Thus, innovation – and technology in particular – is a double-edged sword that some suggest threatens to be the main instrument of our species' undoing (Diamond, 2005; Jenson, 2006; Pitzer, 1970). In fact, the dominant paradigm for sustainable development is based upon the notion of "environmental governance" (Sonnenfeld & Mol, 2002; United Nations, 2002). This model implicitly assumes the problem lies with the environment rather than within our genome and human nature. The basis for our thesis presently, is that this framework is ultimately both self-destructive and self-deceptive. Our goal in this report is to provide the logic and justification for rethinking innovation to be a case of too much specialization rather than the general-purpose or domain-general adaptive trait most people automatically assume it to be.

The idea that the ability to innovate is a general-purpose adaptation in human beings arises from the self-evident diversity of technologies that have been invented to date. From the earliest attempts to harness fire and then basic toolmaking (Chiarelli, 2003) to genetically engineered crops, manned space flight and most recently nanotechnology, it is obvious that innovation has fuelled our unique way of extracting the energy needed to support our rapid growth and prosperity. It has also been instrumental in extending average life expectancy and reducing infant mortality, two of the many factors that impact population growth and demographics. There have been no other working models but Darwin's theory of natural selection (1859) in which to frame the concept of innovation, which has led to its automatic acceptance as a general-purpose adaptation in our species (cf., Barkow et al., 1992; Dawkins, 1976; Dennett, 1995; Hardin, 1959; Huxley, 1944; Wilson, 1978).

Essentially, a general-purpose or domain-general adaptation – because it appears by different names in the literature – is assumed to be the preferred kind of behavioural trait because it provides its owner with the flexibility to switch between available options when it runs into trouble. It doesn't matter why it runs into problems, the point is that either it deals with them successfully or it dies. There are no other options in the simple game of life. Survival is like pregnancy, you either are or you're not; there is nothing in between. To take an example, Steven J. Gould (1989) has argued that an omnivorous diet may have been an important factor that selected for survival in the "winners" found among the Burgess Shale candidates. This means that losers (through evolution's slow and methodical process of tinkering with variation) that were perfectly adapted to their environmental niche had become too specialized. When they encountered pressure, they were not adapted to switch to an alternative way of surviving. Today we have an excellent example in the Giant Panda *(Ailuropoda melanoleuca).* Evolution through natural selection has made it so specialized in its bamboo diet – coupled with its inability to modify itself or its surroundings – that it deservedly earned the status of endangered species. Specialization is evolution's way of improving a species' ability to make the best use of its ecological niche such that it minimizes its overlap (and thus, competes less) with other species for its position within the ecosystem. It is an excellent approach as long as there is environmental stasis. When it changes for any reason whatsoever – and we know it does constantly over geologic time – being too specialized means you do not have the flexibility to change on demand.

The other approach to survival, of course, is to simply wait for a new and useful mutation that allows your species to adapt to the changed environment. But this is precisely why extinction must be among the first principles of evolutionary theory, according to Dobzhansky (1958); the process of natural selection over the course of geologic time simply does not respond fast enough. Those species already in possession of alternative strategies for success are simply more flexible. They survive just long enough to reproduce more often over those that were too specialized or perfectly adapted to their niche. When applied to today's loss of biodiversity, losers simply have not been able to respond quickly to the dramatic changes humans have wrought on the environment.

Lawton and May (1995) reveal that many species have not been fortunate in their struggle to survive the persistence and intensity of the human penchant for innovation. The consensus among biologists is that we know of only a fraction of the species that are presently going extinct.

The public's sense that their species is so well adapted, making it the top predator, leads to an attitude and belief among a majority that humanity, despite all its social flaws, is invincible as species go. The fact that only a miniscule fraction of people fall into the category of Luddites supports this idea. Recent research confirms that only a small fraction actually believes there is any chance our species can become extinct (Pratarelli et al., in press). Upon closer inspection, however, most of those who respond yes to extinction questions believe in nuclear catastrophe, biological warfare or a mutant viral outbreak as modern-day versions of the rapture or Armageddon. Clearly, the paradox of our time is that people believe their species is invincible and at the same time is prepared to destroy itself through technology. That result parallels recent American national public opinion poll results (Pew Research, 2006) that reveal 89% believe Jesus is coming back to judge "the living and the dead"; 20% believe this will happen within their lifetime. This number was as high as 44% nearer to 9/11. This is what it means to be narrow-minded, short-sighted and myopic. In Richard Dawkins' recent book *The God Delusion* (2006), he skilfully demonstrates how people who subscribe to religious belief systems suffer from myopic ways of thinking.

The members of the public are not alone in their short-sightedness. Among some scientists, there appears to be a similar sense of human invincibility, more so among those working in the applied sciences. Their optimism most certainly comes from their far greater appreciation of how science and technology has served the human species in the past. Van Rensselaer Potter (1995) notes that even Charles Darwin "was apparently blissfully unaware of [a] fatal flaw" in the construction blueprint of our species. Another perspective, apparent in Ed Wilson's grandfatherly wisdom, is that only nonhumans are really "endangered" species (2002). *Homo sapiens*, the "serial killer of the biosphere", according to Wilson, isn't likely to become extinct because of its efficiency in hunting down other species to meet its wants and desires. We might well that that this is simply wishful thinking propped up by the mistaken correlation that our large numbers implies we are well adapted to survival. Nothing could be further from the truth, as we'll discover next. What we can take away from all this is that the vast majority of people, including many experts, do not actually believe in the proposition that their species is like those that have gone extinct.

There is another perspective that is often dismissed because it comes across immediately as being nihilistic. This is the idea that humans really may be nearing collapse or extinction, but not because of nuclear catastrophe, overpopulation or other exaggerated claims (e.g., Diamond, 2005; Jensen, 2006). Instead, it is because certain ignored principles of the modern Darwinian theory of evolution are conspicuously evident in the emergent behaviours of global citizens and in the nature of globalization itself: ,most notably, the competitive drive to get ahead and protect the lead, conspicuous consumption, and the seemingly intractable absence of *freedom from want* (Marcuse, 1964). Moreover, we should not be placated or distracted by economists' falsely substantiated claims that humans have an infinite capacity for *adjustment*. Arguments that cite example after example of technological developments, including and especially those supposedly designed to improve living conditions, are simply cases of *not seeing the forest for the trees* (cf., at one extreme Julian Simon, 1998; and at the other Jack Parsons, 1998).

Three Ways to Skin a Cat

The first class of approaches to becoming extinct is the fastest, easiest, and economically most efficient. It is, however, highly improbable where humans are concerned. We can state it plainly and then skip past it to the more interesting and realistic threats to human survival. Catastrophic collapse has happened several times over the course of geologic time, as palaeontologists tell us. A nuclear winter induced by a collision with a large enough asteroid has been one popular explanation for the sudden and mass disappearance of the dinosaurs and all other life forms larger than about 12 inches or 30 cm high some 65 million years ago. There are other catastrophic mass extinction scenarios as well. Modern day weapons technology has the same capacity to destroy so completely. Yet, terrorism, nuclear attacks, biological warfare and the like should be the least of our worries. Alarmists and the public in general are focused on these types of science-fiction scenarios for the very same reasons that people worry about dying in the crash of a jet airliner. The psychology behind these false fears is the concreteness of the imagery. Millions of flights take off and land each year all over the world, and yet only an extremely small fraction ever crash or have problems. The National Transportation and Safety Board statistics show us that there is a far greater chance of being killed on one's way to work each day than dying in an airliner over the course of an entire lifetime of travelling by air.

The Second Way

This second approach involves a grouping of factors that can influence survival and the risk of extinction. Probably the best known one is what happens when multiple bad mutations lead to a form of mutation overdose. Too many of them accumulating in your genotype raise the risk that any one or combinations will pool together and impact your reproductive rate (Lande, 1994). Other factors that could create a reproductive imbalance include "sex, migration and drift" (Amos & Balmford, 2001, as cited in Webb, 2003, p.181). These are incidental to our purposes here simply because they differentially affect survival when the populations are relatively small or near levels considered critical; the problem is that the species becomes sensitive to very small changes in any aspect of the environment (which occur randomly – stochastically) and extinction follows because there are not enough variations left to provide alternative strategies that might be better adapted. In the case of the human species, this is extremely unlikely to have an impact because we have dispersed virtually everywhere and population sizes are extremely robust.

What is most interesting in this second class of approaches, however, is the phenomenon called evolutionary suicide (Gyllenberg & Parvinen, 2001; Rankin & López-Sepulcre, 2005). It has also been called Darwinian extinction: Webb, 2003; self-extinction: Matsuda & Abrams, 1994; and evolution-to-extinction: Dieckmann et al., 1995. It involves asymmetric mating and reproduction. This is a theory that originated with the work of J.B.S Haldane (1932/1990). The basic idea is that the random lethal mutation in a species through inbreeding leads to the extinction of a group over time. A brief example may serve first to put the phenomenon into perspective. We will then review the underlying evolutionary logic.

We will borrow an example cited by Rankin and López-Sepulcre (2005) involving sea cod *(Gadus morhua)*. Commercial fishermen obviously select the largest ones they can catch, leaving little ones behind. To keep reproduction going, the selection pressure favours males who are smaller (because they escape being caught) and early maturation (so they can reproduce)(Olsen et al., 2004). The unfortunate problem, however, is that these faster-maturing males produce smaller numbers of offspring when they do mate successfully. Since late-maturing males were selected out because of overfishing and the smaller fast-maturing ones have low fecundity rates, it means that over time fewer and fewer cod will exist, driving the population numbers down to critical levels where random effects in the environment threaten extinction. In fact, this appears to have been the cause of the collapse in commercial cod fishing (Olsen et al., 2004) in recent years. For the same reasons identified in the first extinction scenario above, humans appear to have very little to fear from this condition, again because numbers and dispersal across the planet are large enough to overcome any reproductive asymmetries.

The Third and Final Way to Reach Extinction

Our last extinction class received considerable attention a half century ago but then interest appears to have dwindled. The focus of this case is the overspecialization of a species to its ecological niche. Too much reliance on a narrowly defined niche (specialization) may compromise a species if the environment should change in less time than the random process of mutation (according to Haldane's calculations, a minimum of one beneficial mutation every 300 generations) can provide the needed adaptation to increase variation in the species-specific DNA. The main proponent of this extinction condition was Theodosius Dobzhansky (1958), who argued that should a species become too perfectly adapted to its niche, it is predictable that, through geologic time, their niche will change and they will not. Potter (1995) has labelled this phenomenon a "fatal-flaw" syndrome.

Of course, others besides Dobzhansky have raised the extinction by overexploitation concern over the years (cf., Leopold, 1933; Ehrlich, 1966; Hardin, 1968; Commoner, 1971; Potter, 1988) and provided a sound but debatable foundation for their argument. Hindsight, they say, is 20/20, but we believe that projections kept in their proper perspective should be alerting policymakers and the public more than ever that extinction should be much more than an absurd abstraction or an alarmist exaggeration. Presently, our purpose is to draw attention to certain ignored evolutionary principles that we believe can be appreciated much better today than in years past. In light of recent advances in the neurosciences, anthropology and evolutionary psychology, there should be much more cause for concern than presently exists.

The working logic for the extinction proposition follows first from Dobzhansky's principle (1958) that extinction is the fate of most species because it is "built into the evolutionary process" (Potter, 1995, p.109). There is in fact "no biological law [that] can be relied upon to insure that our species will continue to prosper, or indeed that it will continue to exist", given the increasing pace of all forms of technological and cultural innovation (Dobzhansky, 1958). Secondly, despite the ubiquitous nature of cooperation in our species, it is built upon a far more primal instinct to pursue short-term gain at the expense of long-term survival (Potter, 1995; Pratarelli, 2003; Shackelford, 2006). Third, evolution moves a species unintentionally toward perfection by favouring those individuals best adapted to the *existing* environmental conditions. It follows, therefore, that evolution cannot foresee the future, nor can it foresee what any given adaptation may do to alter the environment in such a way as to render a once adaptive trait obsolete. This condition is also attributable to

Dobzhansky "because selection promotes what is immediately useful, even if the change may be fatal in the long run". The evolved trait in question, of course, is that which we raised at the outset, our predisposition to innovate, specifically through science and technology.

The problem has grown so much that it has outstripped the ecosystem's ability to naturally renew itself (Worldwatch Institute, 2007). Thus, we have to ask the same question raised by Aldo Leopold (1933): whether technology may someday outlive its usefulness. Without wandering into the naturalistic fallacy trap (Moore, 1903), we can stipulate that moralizing humans favour survival over extinction and thus argue that it is in our best interest to do something to intervene in this biological process. The problem with this logic is that it conflicts with the general perception and opinion of many experts and the public alike, that technology and innovation are a general-purpose adaptive trait. If this assertion is true, then it follows that we have nothing to worry about in the future because we will, in time, develop the needed curative science and technology to restore balance in the precarious relationship between humans and the natural environment. The consumption, growth and pollution trends, however, contradict this (Worldwatch Institute, 2007).

If we now take into consideration the fact that any given evolved trait an organism possesses can range along a continuum anchored at one extreme by overspecialization and at the other by complete flexibility, then we need to ask where innovation should be placed. Recall that in the case of the Giant Panda, its adaptation to a very specialized diet places it in a compromising position probably near the extreme of the continuum. Next, we intend to argue that innovation has been incorrectly conceptualized by scientists and the public as a general-purpose adaptation at the opposite pole. Instead, technology needs to be re-examined without bias by asking whether the evidence is there to suggest it is another case of overspecialization. We believe the evidence objectively speaks for itself. The consequences if it is a case of too much specialization may be disastrous in a very short amount of time without a major adjustment in course.

Innovation and Obsolescence

On what basis can we argue that innovation in general and technology in particular are cases of overspecialization to the environmental niche? Our first and principal assertion is that the history of technology reveals a monotonic function, meaning that it has progressed in a single direction. The directionality of that function is an inherent property of innovation in that new developments are motivated by a need to improve an existing condition. There simply are no reasonable examples in the anthropology and social science literature of a time when people *voluntarily* gave up their investments in technology. There have been abandonments as in the case of the Anasazi Puebloans of the Southwestern United States in the 14th century, but these have been involuntary, the Anasazi being driven out of their cliffside dwellings by prolonged drought or other environmental pressures.

On this count, technology continually adds to the human activity infrastructure, making it increasingly difficult as time passes for people to give it up. In fact, recent studies confirm our intuitive understanding that most people cannot slide back into a previous state with older and less advantageous technology without extraordinary efforts (NSF, 2006). Rare exceptions exist, of course, in virtually all societies – e.g., Buddhist and Franciscan monks take vows of poverty; and small groups of individuals, often with religious incentives, opt out of the frenzied pace of life driven by technology – e.g., the American Amish or the "back to nature" movement of the 1960s. Presently, a small movement within environmental circles called *Voluntary Simplicity* has not attracted many converts either (Etzioni & Doherty, 2003). At a conscious level the conflict individuals face is their perception that they would leave themselves and their kin at a competitive disadvantage in the social, political, and economic arenas. At an unconscious level, however, doing without simply contradicts the innate self-interest motive (Potter, 1995; Pratarelli, 2003; 2005).

Our second assertion depends on the assumption that technology is part of cultural development (Chiarelli, 2003). Individual cultures and societies often derive their unique identity from the technology they adopt. Once adopted, a technology may be improved upon but never entirely discarded. This is the underlying basis of cultural tourism. People travel to see and experience the architectural technology and customs of other regions. In fact, it is the mighty tourism dollar that creates tension between local citizens wanting the benefits of modernization and those relying on the marketability or draw of the original state. Owing to the reluctance to give up old identities in such cases, retrofitting has become a necessary engineering emphasis. Few cities remain that are not doted with parabolic dishes atop their roofs to access television programming; and before them rooftops were a forest of antennas. The discarding of older technologies in favour of new ones is also an identifying feature of globalization. The tendency of diverse cultures to move in the direction of Western standards, practices and the adoption of modern technology, is a case of regression toward the mean, where the mean is characterized by a biological ethic or ideal we can label 'increased advantage'. Commercially and religiously it is represented as "prosperity."

In the third assertion, a cost-benefit analysis provides the momentum that keeps existing technological styles in place, thereby preventing newer ones that might be simpler and cleaner in design from replacing them. The problem is the cost-benefit tradeoff where neither is defined exclusively in economic ways. Arguably, the aesthetic value of having a single electricity generating coal or gas-powered plant in a small centralized location is greater than covering thousands of acres with solar panels and windmills. This is the problem facing the development of "green technologies." They are not always perceived to be economically feasible to the individual nor are they always as efficient at the outset, which inhibits their being adopted universally. At present, they satisfy a very small fraction of the planet's energy needs, inasmuch as 80% comes from fossil fuels and the balance from nuclear (Holdren, 2007) and hydroelectric. An external psychosocial force is required independent of the technology to motivate people to adopt it. As whole populations begin to warm up to the pressure of a changing environment, as in the case of global warming or ozone depletion, they begin to demand newer technology even if the front-end costs are higher than what they presently pay to extract their energy needs. Moreover, until such time as conservation practices are appreciated as economically feasible to the average consumer – unconsciously driven by short-term gains – they, too, will continue to wane until the environmental costs become too great for them to bear.

Taken together, these three forces not only drive the innovation engine forward unidirectionally, but they also insulate or prevent it from making necessary course corrections that would favour the long-term survival of our species and the rest of the ecosystem. Potter (1995) has articulated this evolutionary conflict best when he says that "in pursuing perfect adaptation the evolutionary process has built into each member of the human species an instinct for short-term gains so strong that no prescient individual, committee, religion, or private organization has so far been able to conceive or effect a cultural milieu that could adequately balance the short-term instincts of human individuals with the long-range needs of the species" (p.107). This biological motive is complemented by the impulse to innovate. According to the model we elaborated above, technology as the physical manifestation of our "innovation" adaptation is becoming increasingly specialized, thereby impeding or preventing outright our ability to respond fast enough to environmental pressures, which by some accounts may be the product of human activity. Whether it is or not is entirely irrelevant to our argument.

There is no question but that given the split second in geologic time that human technology has transformed the biotic and geophysical environment, it is delusional to sit and await the appearance of a useful adaptive mutation. As Leopold called for three-quarters of a century ago in the form of a species-wide conservation movement, and Potter called for in a cultural revolution in thought based on an evolutionary understanding of the delicate relationship between humans and their natural environment (what he termed *Global Bioethics*), the environment is demanding a change in our behaviour sooner rather than later. Otherwise, we run the risk of triggering Dobzhansky's extinction principle sooner than we would like. As Potter argues in the above quote, existing social and political institutions are not positioned presently to address these environmental pressures. We're inclined to extend that observation even further and argue that in fact these institutions are working against our species' long-term best interests by intensifying our impact (Chiarelli, 2003, v.3;

Pratarelli, 2003). We see this manifested in the intense social pressures being focused on propositions like "prosperity," "success," "strength," "growth," etc. All of these are part of evolutionary ethics (Spier, 2004), but collectively they can be lethal.

If we attempt to map the case of humanity's adaptation for innovation – as we have described it in the three assertions above – onto Potter's "fatal flaw" analysis, which he based on Dobzhansky's evolutionary "fact" or principle, what we end up with is a case of overspecialization rather than general-purpose trait. We believe there is far more evidence in the current human condition, globally, to suggest a parallel with the Giant Panda than the ubiquity of an omnivorous scavenger. A belief in new and more powerful technologies as the ultimate solution is not warranted when we examine the history of how it has normally been put to use for short-term gain, power and corporate exploitation. Prudence (vis-à-vis the precautionary principle) demands that we carefully examine both our motives and the ethics of new technology, especially where it concerns biotechnology, and ask whether we are truly balancing our interests with those of the global ecosystem. This of course, must be done in such a way that we preserve those conditions that nurture, support and preserve human dignity, something that has yet to be achieved by our species. Believing that even more technology is the solution to all of our problems may be a case of species-wide self-deception and denial (Pratarelli, 2003). The false belief in technology as savior replaces the truth that we're digging ourselves deeper into a pit from which we may not be able to emerge in time to avoid the next in an ongoing series of mass extinctions.

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