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EDUCATION FOR THE ANTHROPOCENE
How the Orphan Disciplines Undercut Freedom

"If you wish to make an apple pie from scratch, you must first invent the universe." – Carl Sagan

The rapid global deterioration of environmental conditions during the last century has significantly impoverished human well-being in many parts of the globe and jeopardized species with which humans share heritage and destiny (Kosoy et al. 2012, Rockström et al. 2009). Much of the Earth's fresh water is contaminated, in short supply, or subject to competing claims (MEA 2005). The pattern and rate by which human society consumes non-renewable energy sources greatly impede an energy transition to more sustainable sources (IEA 2012). Greenhouse gas emissions from human activities are changing the atmosphere and overwhelming the ability of natural systems to absorb them (IPCC 2013, World Bank 2012). To respond to threats, there is an urgent need to re-conceptualize, retool, and apply the social sciences and humanities in a novel way, rigorously informed by the natural sciences.

We join Karl Polanyi in lamenting the rise of the concept of the self-regulating market dis-embedded from traditional society. But our concern is far broader and the situation is urgent even beyond that of the first half of the dismal 20th century. For what we teach in higher education in many of the social sciences and humanities is an interpretation of the world that is largely uninformed by the advances of the sciences of the last two hundred years. The prevailing education model confines the teaching and study of the economy, society, ethics and the environment within largely isolated departments, with insufficient opportunity to weave disciplines together in order to solve multi-faceted socio-ecological problems. For example, economists have considerable influence on environmental policy, yet typically receive their degrees with no requirement to study ecological foundations of society. Likewise, philosophy doctorates study ethics, belief systems, and the fundamental elements of the human condition, but often without grounding in biology or behavioural sciences. The natural sciences have built a coherent foundation from which to build the study of society and humanity, but their academic departments often treat human systems as an external driver to their problems of study, rather than integral to the whole.

Multidisciplinary and interdisciplinary initiatives have made some progress in educating students to the multi-faceted nature of the current human predicament, but they rarely

question whether individual disciplines are authentic and scientifically sound. In what we call the “orphan” disciplines – fields of study wandering the halls of academia who have long since lost their metaphysical parents – we give students maps of the world; but they are not maps of where we are. As a result, higher education is strongly complicit in the unraveling of the Earth’s life support systems and the accelerating decline in life’s prospects. What Polanyi saw was but the tip of an enormous and lethal iceberg; lurking to sink the ship of civilization itself. Yet the very structure of higher education blocks the development and exercise of the freedom that Polanyi saw as essential in a complex society.

This paper will focus on re-grounding a select group of orphan disciplines, in part by expanding and deepening the approach of ecological economics. In contrast to environmental economics – a sub-discipline of economics that applies the established map of economics to environmental problems – ecological economics is the study of the economy as a social system embedded in containing and sustaining earth systems. We will integrate both theoretical and practical research to strengthen the potential for the pre-analytical vision of ecological economics to address the “two cultures" problem that has kept the natural sciences on one side of a methodological and evidentiary divide and many of the social sciences and humanities on the other (Snow 1959, Spash 2012). In turn, this will enhance society's potential to address the rapidly deteriorating situation we have created for ourselves.

The Natural Sciences: Branch or Base?

Advances in twentieth century science were largely defined by the tradition of reductionism, the practice of analyzing and describing complex phenomenon at every smaller physical scales and processes. In a scientific process called "consilience by reduction", biologist E.O. Wilson (1998) describes the success of the natural sciences in carefully ordering and linking knowledge across a hierarchy of temporal and spatial scales of study as a "jumping together of knowledge by the linking of fact and fact-based theory across disciplines to create a common groundwork of explanation." What is learned in an ecology class about the interaction of organisms from niche to ecosystem scales, and from generational to evolutionary time scales, is largely consistent with the building blocks of biology, chemistry, and physics.

Where untested theory within the natural sciences has yet to deliver hard-won fact is at the very edges of scale and time, from the sub-atomic level to the origins of the universe. The frontiers of science are also challenged by what Wilson calls "consilience by synthesis," where knowledge of the parts is used to predict behavior of the whole. Along this direction of causality is where the union between the natural sciences, social sciences, and humanities is both a leading edge of twenty-first century science and the source of solutions to our most complex problems. However, a fundamental challenge is that much of the social sciences and humanities persist as both internally inconsistent and externally disconnected to each other and the biophysical foundations of human civilization. Interdisciplinary and transdisciplinary teaching and research have made some progress in educating students to the multi-faceted nature of the current human predicament, but they have not recognized that some of our

dominant disciplines have little or no systematic relationship with current scientific understandings of the Universe or our place in it.

What if the natural sciences were seen as foundational to the social sciences and humanities, rather than a competing branch of knowledge? What if fields of study within the social sciences and humanities developed from a metaphysical view that embedded humanity within the Earth's biogeochemical systems, subject to the physical laws of the Universe? What if traditionally normative fields such as economics, finance, governance, law, and ethics – fields that tell us what we ought to do – were informed by the more positive disciplines of physics, chemistry, and biology? Economics prescribes growth; finance how to manage personal, corporate, and public wealth; law the rights of property owners and the boundaries of legally allowable personal conduct; governance the legitimate powers of the state and other bodies; and ethics the privileges and duties of individual persons. Where does the "ought" of the normative conflict with the "is" of the positive?

Herein lie the revolutionary and necessary questions that open up a fresh and hopeful vision for the future. In our age we have a better understanding of the cosmos than at any time in history. The scientific narrative that begins with the big bang and extends to the emergence of life on earth (Christian 2014) provides a new perspective from which to build the study of human economies and institutions, to guide public policy and governance, and to provide a new foundation and ethics that could help guide humanity through the planetary crises of climate change, mass extinction of species, and social conflict over growing human demands on dwindling planetary resources. This is not to say that the modern scientific synthesis provides a complete understanding. Much remains mysterious, such as competing theories of the role of dark matter that makes up a large percent of the universe. And the quest cast by the Enlightenment for a "theory of everything" – uniting the micro world of the quantum to the macro world of general relativity – remains elusive. But because we don't know everything does not mean we don't have a fresh vision of our place in the Universe.

Re-grounding the Human-Earth Relationship

Until around 1800 mainstream western civilization took its cosmological bearings primarily from two main sources. First, from the book of Genesis of the Hebrew Bible – what Christians call the Old Testament – written down according to biblical scholars around the 6th or 5th century BCE. The second major source was the works of Aristotle (384-322 BCE) a student of Plato; as well as the Alexandrian astronomer Ptolemy (90-168 CE) who held that the sun revolved around the Earth. In its many facets and many journeys over millennia, this tradition has been characterized by a deep dualism: humans are taken to be separate from and fundamentally different than the rest of life and from nature itself. These sources were combined into a powerful synthesis by Thomas Aquinas toward the end of the 13th Century. Of course, in the centuries that followed the synthesis was not without its powerful critics whose names shine brightly in the history of science: Copernicus (1473-1543), Galileo (1564-1642), Kepler (1571-1630), Newton (1643-1727), Darwin (1809-1882), Planck (1858-1947), and Einstein (1859-1955) to name just a few.

Beginning in the early part of the 19th century a new perspective began to take center stage in the work of the Scottish geologists who insisted that the Earth was of very ancient origins and was subject to slow changes over millennia. This helped to lay the groundwork for Darwin's *On the Origins of the Species* published in 1859, which is incompatible with the idea that humanity is specially created as asserted in the Book of Genesis. The discoveries in the later part of the 19th and the truly revolutionary 20th century lead to a new synthesis built around the ideas of complex systems and evolution and undercut the ontological dualism central to the older understandings of the human place on Earth and in the Universe. This has fundamentally changed our understandings of our relationship with life and the world.

Remarkably, the deep dualism embedded in Western culture from its inception remains a powerful force in the academy and world alike. In particular, contemporary science has not adequately informed the conventional view of humanity's relationship with the Earth reflected in very influential domains such as economics, finance, law, governance, ethics, and philosophy. Grounded in 17th and 18th century European Enlightenment versions of the Thomistic synthesis, these systems of thought have remained largely uninformed by the developments of 19th and especially 20th century science. We should think of these and other disciplines as orphans – their intellectual parents are dead, but they remain alive in pedagogy and practice. Limited adoption of the orphan disciplines to new parents within the natural sciences has occurred through multidisciplinary or interdisciplinary endeavors. However, to extend the metaphor, these collaborations are more often viewed as marriages of consenting adults with equally relevant perspectives, than as adoption by new parent disciplines. In short, these efforts often operate on the assumption that disciplines are well grounded and authentic, but they rarely question whether individual disciplines are scientifically sound or consilient with one another.

More transdisciplinary fields that question the artificial boundaries between disciplines have made some progress in sharing a basis for problem-solving between fields that have traditionally come from competing ontological views. For example, ecological economics has been framed as the study of the economy as a social system embedded in containing and sustaining earth systems. This grounding of economics in the biophysical foundations of ecology has not been without challenges, as most recently reviewed by Spash (2012). However, the unfinished journey of ecological economics does provide an intellectual map from which to identify candidate parents for the orphan disciplines.

Adopting the Orphan Disciplines

Orphan disciplines can be divided into a least two groups. First, there are several normative structures that shape and mediate humanity's relationship with life and the world. These are directly prescriptive, and include disciplines such as economics, finance, law, governance, ethics, and philosophy. At the same time however, there is a much broader set of disciplines that also suffer from deep ontological inconsistencies with the contemporary scientific synthesis. Engineering takes it for granted that the Earth belongs to humanity and may be significantly modified, often at will, to suit our (even whimsical) purposes. Conventional agriculture assumes that "food security" applies only to persons. More broadly, it can be

argued that many of the social sciences are orphan disciplines in that they rely on the assumption of a sharp nature-culture divide (Kohn 2013).

In order to constrain the scope of our critique and resulting project we consider three clusters of normative disciplines: economics and finance, law and governance, ethics and philosophy. After briefly describing these clusters we show how inquiries from ecological economics can help to build a bridge from emerging explorations in the sciences to these disciplines. We end by asking: can a fresh approach to education for the Anthropocene emerge from these efforts?

Economics and Finance

Conventional economics is mostly taught and used in the formulation of policy without any systematic connection to understanding of biophysical processes of supply and neurological foundations of demand. In contrast, ecological economics provides an alternative that frames economic production as a science with biophysical imperatives, building on the progressive work of Soddy (1935), Boulding (1966), Georgescu-Roegen (1971), Daly (1977), Victor (2008) and Jackson (2009). Contextualizing the social and cultural foundations of economic exchange is developing through such work as Ostrom (1990). A more recent reconstruction of the core behavioral model of economic consumption is underway with alliances with neurobiology and the behavioral sciences (Gintis 2000).

Like economics, finance is taught as a self-contained system with no clear mechanisms to account for environmental limitation or unfair outcomes (Bodie et al 2008). The recent global financial crisis has sparked renewed interest in Minsky's explanation of the inherent instability of the financial economy (Minsky, 1986). With the development of modern money theory, economists such as Godley and Lavoie (2006) and Wray (2012) have advanced understanding of the distinctive characteristics of financial capitalism, but their insights remain largely unrelated to the biophysical dimensions of the economy. However, the flows and uses of money influence the world's biophysical systems profoundly; they influence who is rich and who is poor exacerbating the inequality of wealth distribution and political power. They are inherent drivers of the loss and fragmentation of ecosystems, extinction of species, overexploitation of natural resources, and a changing climate that place humanity outside of what is considered the planet's "safe operating space" (Brown 2012; Rockström et al. 2009).

Law and Governance

A key postulate of liberal politics is that people may live how and where they wish, pursuing what John Stuart Mill called purely self-regarding actions (Mill, 1869). Yet, ecology and thermodynamics, plus the overwhelming evidence concerning anthropogenic causes of climate change and of the destructive effects of contamination of air, water and arable lands, clearly reveal that such acts are rare at best. Recognizing this, a grounding of law and governance with contemporary science might start with the suggestion in Rockström et al. (2009) of the need for novel and adaptive governance approaches from local to global levels, based on planetary boundaries which define limits (Galaz et al. 2012).

A foundation of law in many liberal cultures is the strict protection of private property defined in a purely anthropocentric perspective. However, the main thrust of current scientific

understanding, particularly ecology, directly challenges the idea of severability on which a liberal understanding of property depends and underscores the interconnection between public goods and private property. In addition, the assumption that humans are the sole rightful owners of the Earth is difficult to ground in an evolutionary worldview. We will need to advance a more holistic approach to the law that recognizes ecological limits and interdependencies, and that humans co-evolved with the rest of life, building on such work as Rose (1997), Solan (2002), Hornstein (2005), Ruhl (2012), Garver (2013), Cullinan (2011), Bosselmann (2008), Ostrom (1990), Ost (2003), Burdon (2012) and Grinlinton and Taylor (2011).

Ethics and Philosophy

Ethics and political philosophy in the 20th century, at least in the Anglophone countries, have largely focused on whether to emphasize human rights or utility. Yet, neither tradition has been firmly grounded in more sophisticated contemporary understandings of human subjectivity and social and ecological interdependencies. In the early 20th century, Bergson (1911), Schweitzer (1987), Whitehead (1978) and others began an "organic" counter movement that began to articulate an integrated understanding of the relationship between the human self and the world. This inspiring counter-perspective has come back to life as thinkers like Leopold (1949), Callicott (1994), Jamieson (2002), Berry (1999), Elliott (2005) and Brown (2012) have explicitly sought to connect ethics to science. Indeed, contemporary science supports and situates understandings of the self and world that are contained in many of the world's ethical and religious belief systems, and in the work of philosophers such as Spinoza.

The insights of neuroscience in particular help to understand how humanity can access and experience fundamental connections to a creative Universe, and undergird the construction of new narratives of humanity's place in it, including its responsibility to future generations (Lakoff and Johnson 1999; Nadeau 2013). New frontiers of investigation and understanding are emerging such as Hauser (2006) and Wilson (2002). This work outlines a need to advance the dialogue between moral philosophy and the insights from contemporary neuroscience, evolutionary biology and cosmology Chaisson (2006), and complexity theory Kauffman (1995).

Ecological Economics as a Leading Experiment in Re-grounding the Human-Earth Relationship

If the academy is to be relevant in addressing the ecological crises of our time, then research should purposefully consolidate worldviews between the natural sciences, social sciences and humanities. This consolidation has some success in the more "positive" social science disciplines such as psychology and anthropology that have formed alliances with the natural sciences based on neuroscience and evolutionary biology. However, there is less discourse with the intellectual traditions of the more normative disciplines of the social sciences and humanities, a principal focus of this paper.

Ecological economics provides one compelling example of building a study of the human economy that is: (1) viewed both as a complex social system and as one embedded in the biophysical universe; (2) grounded in the evidentiary standard of physical and biological sciences; and (3) framed in a problem-solving approach built on methodological pluralism that

borrows broadly from many fields (Gowdy and Erickson 2005). Alternative research approaches that have resulted include the development of multi-criteria decision aides, moral actor models, socio-ecological modeling, and biophysical assessment and synthesis. As these examples show ecological economics provides insights that show how the ``orphan` disciplines can be informed and altered by following modes of inquiry from ecological economics. In what follows we concentrate on the discipline of economics as an example.

Multi-Criteria Decision Aides

A significant literature critiques the monetary foundation of cost-benefit analysis in economics, including the implicit assumption of substitutability between human-made and natural capital (Gowdy 1997); the phenomena of "crowding-out" moral behavior with the introduction of monetary values (Frey and Oberholzer-Gee 1997); the importance of lexicographical preferences in evaluating trade-offs between economic, social, and environmental goods or services (Spash and Hanley 1995); and the existence of hyperbolic discounting in evaluating medium to distant future outcomes (Laibson 1997). Ecological economics favors "values plural" approaches such as multi-criteria decision analysis that explicitly address the biological, social, and complex nature of human decision-making (Kosoy et al. 2012, Martinez-Alier et al. 1998).

Moral Actor Models

Standard economic analysis starts with a rational actor who makes decisions without regard to social or environmental context. *In contrast,* game theory experiments and laboratory results involving actual human behaviour cast doubt on the general validity of a model built on assumptions of an isolated individual at a point in time. Preferences are dependent on social context, individual histories, and conscious preference development (Albert and Hahnel 1991). An ecological economics model incorporates a sense of fairness and socially contingent decision-making rooted in the biology of moral reasoning (Fehr and Gachter 2002). Models of decision-making such as "prospect theory" (Tversky and Kahneman 1981) and "biased cultural transmission" (Henrich 2004) have proved to be better predictors of economic behaviour than the axiomatic rational actor model.

Socio-Ecological Modeling

The primary unit of analysis in economics is at the margin, with "efficiency" criteria as the golden-rule for resource allocation. *In contrast,* complex socio-ecological systems exhibit discontinuity, irreversible thresholds, emergent phenomena, and co-evolutionary change. Evolutionary change is characterized by hierarchies of selection, historical contingency and random events (O'Neill et al. 1986). In evolutionary systems it is impossible to change one thing and hold everything else constant. The existence of qualitative and non-marginal change argues for rejecting microeconomic theory as a foundation for macroeconomics (van den Bergh and Gowdy 2003) and instead embracing the science of complexity and coupled human-natural systems models in ecological economics (Liu et al. 2007).

Biophysical Assessment and Synthesis

Conventional economics treats production as an allocation of given resources without regard to biophysical processes. *In contrast,* ecological economics is instead grounded in material and

energy throughput analysis, including measurement and models of ecological footprint (Wackernagel and Rees 1998), human appropriation of net primary production (Haberl et al. 2007), and spatially explicit generation, delivery, and demand of ecosystem services (Kareiva et al. 2011). Ecological macroeconomic systems modeling is now emerging to investigate strategies for growth-neutral or degrowth economies (Victor 2008, Jackson 2009, Kallis 2011).

Toward an Education for the Anthropocene

There is a symbiotic process of legitimation between institutions of higher education and other institutions in the world. Those who march to the tune of "pomp and circumstance" with "parchment" in hand often endow the programs they attended. But the legitimacy of both practice and discipline is erased once the tenuous, nearly nonexistent relationship with contemporary evolutionary and complex systems science is exposed. As currently constituted, they ought to be regarded as a kind of *zombie jamboree* (our minds being possessed by the dead) or a *danse macabre* (laying waste to the planet) rather than as a triumph of the human mind and spirit. This is not to say that there are no useful ideas in these disciplines or wisdom in the actions of institutions; but it is to say that their *structures* are fatally flawed.

In what we call the "orphan" disciplines we give students maps of the world; but they are not maps of where we are. Most universities have "sustainability" efforts to reduce the impact of the operations such as CO_2 emissions. These efforts are often successful and laudable; but they are radically undercut by what is taught in the classrooms of many disciplines and professional programs. As a result, higher education is strongly complicit in the unraveling of the Earth's life support systems and the accelerating decline in life's prospects.

The aim of this paper is not to reduce the normative orphans to the sciences, but to use the powerful and still emerging insights of contemporary science to integrate these frameworks into a common narrative. The door opened by ecological economics provides such an opportunity. We are just at the beginning of a great journey of discovery of our place in the cosmos and the implications of that place for ourselves and the rest of life with which we share heritage and destiny. The findings will be revolutionary, frightening, unsettling, and full of opportunity. This is the challenge that the Anthropocene offers higher education: to cast off the cobwebs that entangle us and promise little more than a continuation of our current journey into oblivion. A path through the thicket is before us.

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