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AS I SEE IT

O Canada, o quanta qualia

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ABSTRACT: The ecological effects of warming and freshening ocean waters in the Arctic have been discerned, but narratives are needed to unify these objective scientific states of material being with subjective humanistic states of ideal knowing. Here, the physicality of nature and the spirituality of humanity point towards a putative unification that transcends two self-consistent but non-overlapping frames of reference.

KEY WORDS: Arctic · Complexity · Science philosophy · Simplicity

O CANADA

'Our home and native land'. This phrase resonates in about 34 million of this planet's 7 billion human inhabitants. The home and native land of Canadians is the terra firma situated north of the metaphorical 49th latitude on the American continent. On a moment's reflection, and with further hearkening of the anthem, we realise that the broad domain includes all that is beneath the shining skies and all that is circumscribed from sea to sea: 2 oceans connected by a third. And yet, that we know (transcendental) and what we know (experiential) seem incomplete (Low 2008). In the words of 'o quanta qualia' first sung long ago by Pierre Abélard (1079–1142), there is more, and there is better. Indeed, our home is the universe (Kauffman 1995) and the unveiling of simplicity from complexity is ineffably sublime.

ARCTIC JOURNEY

Take a journey to the Arctic Ocean starting from Resolute. You can reach this Inuit hamlet by sailing from the Pacific Ocean through the Bering Strait, or from the Atlantic Ocean through Baffin Bay. If you are a circumpolar resident, you do not have as far to go as southerners. Otherwise, take a virtual journey. Use Google Earth to zoom down from outer space. Superimposed on the physical landscapes and seascapes, you can overlay features of the ecological, economic and social systems. If you zoom slowly, you will work your way down from planet Earth to the western hemisphere, to North America, to Canada, to Nunavut, to the Arctic Archipelago, to the Qikiqtaaluk Region, to Cornwall Island, and finally to Qausuittuq (Resolute). With luck, you may even see the Canadian coast guard ship 'Louis S. St. Laurent' at anchor in the bay. From there, journey to the Canada Basin of the Arctic Ocean. Drop a bucket over the side of the ship, bring in the water, and peer into a microscope to see the life forms. But do not stop there. Take the life forms and investigate the smaller parts of which they are made. Lay out their DNA sequences and figure out the recipe for life. It does not take long to realise that every physicality we encounter from the outer space of the planetary realm to the inner space of the living forms is reducible to the same material elements. However, we clearly cannot deny that things are different at every level of perception. This means that building up from scratch is

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not necessarily a simple matter of adding up all the component parts. Process becomes crucially important. The ontology of becoming defines the state of being. This is the quintessence of why apparently disparate complex systems (ecological, economic, social) seem to work in the same way. But I am getting ahead of myself; back to oceanographic science on board ship in the Canada Basin.

OCEANOGRAPHIC SCIENCE

The physical task at hand is straightforward and one that has occupied oceanographers for many generations: measure the seawater temperature, the salt content, the nutrient concentration and the phytoplankton abundance. Of course, early oceanographers would not recognise the modern electronic instruments and would be astonished at the acquisition speed, accuracy and precision of the measurements. Tellingly though, they would immediately recognise the mechanistic paradigm of directed causality framed in the logic of formal argument (Homer-Dixon & Karapin 1989). There is a claim (ecosystem change), some data (temperature and salinity change), a warrant (phytoplankton change), and backing (nutrient change). Logic dictates that we can accept the data, warrant and backing but still deny the claim because warrants do not force a necessary conclusion. Indeed, we must leave this particular claim unsettled for now, even in the light of supporting empirical evidence. The smallest algae thrive as the Arctic Ocean freshens in a changing climate (Li et al. 2009), but ecosystem change is merely a warranted inference. More problematic however is the sense that mechanistic causality does not seem to work very well in living systems. For an engineer, this problem is disconcerting because it may represent an epistemological limit; but for a scientist, it is an invitation to open a new window into nature (Ulanowicz 2009). Others, it seems, are also looking for an alternate metaphysic and ending up at the same window (Homer-Dixon 2009) opened to them by ecologists (May et al. 2008).

CAUSAL ATTRIBUTION

The Arctic causal chain starts with temperature and salinity. To oceanographers, these are so-called conservative properties, because away from the sea surface, they do not change except when water is mixed. Their observed behaviour is a statistical manifestation of an immense number of unobserved identical particles whose individual mechanics are averaged. The next link in the chain is inorganic nutrients. These are non-conservative properties because they can change, even in an isolated system. Nutrient changes are quantitative, not qualitative. Nitrogen is transformed in a cycle, but the members (NH_4, NO_3, NO_2, NO, N_2O, N_2) of this cycle never become something else, such as phosphorus. At the end of the chain, we look for the phytoplankton. This is easier said than done because phytoplankton are not only non-conservative, but they are acclimative and adaptive. This means that they have organisational plasticity and under pressure of selection they can evolve. Ask a scientist what he or she means by temperature, salts and nutrients and you will likely get the same answer; not so for phytoplankton.

To many physicists, phytoplankton are synonymous with fluorescence: the release of photons as electrons return to ground state after excitation. Thus, the physics proxy of biology (fluorescence) and actual physics (temperature, conductivity) can be coincidently profiled in the ocean using a single integrated electronics package that is the indispensable workhorse of modern oceanographic surveys. To many chemists, phytoplankton are synonymous with $C_{55}H_{72}O_5N_4Mg$ (chlorophyll *a*), a diagnostic molecule that can be measured with great analytical precision by chromatography when disaggregated from its native state in a test tube. However, biologists find themselves between the Scylla of the ecological hierarchy (proteins to organisms to populations to functional groups to communities) and the Charybdis of the evolutionary hierarchy (genes to organisms to demes to species to monophyla) (Eldredge 1985). The biological entity called phytoplankton is suffused throughout this dual hierarchy. It can be found as a genetic pool, as a morphological mass, as a unit of biogeochemical agency, or any other token that occupies the economic (ecologic) or informatic (genealogic) hierarchies. Where, if any place, in these systems do we focus to find the causal link between climate change and ecosystem change? Indeed, could we even expect, in principle, to establish a chain of attribution from climate change to biological change (Parmesan et al. 2011)?

HIERARCHIES AND PROCESSES

Triumphant reductionism views the earth to be inhabited by a set of nanobiological machines driving electron transfers that are coded by a set of core

genes, all housed in vessels (called organisms) that serve as temporary guardians for the essential reactions of life (Falkowski et al. 2008). This is the drive to unification through non-composed simplicity, that is to indivisible elements (Low 2008). Heterodox holism views the entire biosphere acting as a single entity to homeostat the planet for an optimum physical and chemical state appropriate for the total ensemble of living organisms (Lovelock 1972). This is the drive to unification through non-complex simplicity, that is to reducing the number of unknown relations (Low 2008). I prefer a mid-level focus at the nexus of the Eldredgian dual hierarchies, namely the individual organism, where the gene meets the environment. At this level, organisation can become sentient and in one case noetic. We alone, amongst everything else, can contemplate how the statistical mechanics of particles of one kind might be related to the contingent propensities of particles of another kind. In so doing, we can explore the middle ground between 'the quick and the dead' (Ulanowicz 2002) that is between the living and the non-living universe. How does it all start and end?

Consider phytoplankton. At any level of the ecosystem hierarchy, there is a resilient cycle of processes looping from growth (*r* phase), to conservation (*K* phase), to collapse (Ω phase), to renewal (α phase), and back to growth (Holling 2001). It is not difficult to map this template onto the annual cycle of population dynamics, say of the phytoplankter *Micromonas*, in the Arctic Ocean. At times, these phases make connections across to other levels in the hierarachy, creating a nested set of cycles, hence a pan-hierarchy or panarchy (Holling 2001). Thus, we might imagine an invigoration of the *Micromonas* population linked to innovations propagating upwards from cellular and subcellular levels, and also a stabilisation of the population linked to legacies cascading downwards from the larger community of plankton.

Theorists offer a triadic system of causation: namely a focal level of co-interaction, a component level presenting the possibilities of initiating conditions, and an encompassing level presenting the constraints of boundary conditions (Miller 2008). The interplay between bottom-up and top-down propensities sets a poise that may become unbalanced when sufficiently perturbed. A chance then arrives to admit something otherwise unexpected, becoming contingent history recorded into the enduring memory of the system. In a plankton food web, the normal balance of the predator–prey cycle may be disrupted by physical or chemical perturbations, opening loopholes into which normally obscure species may explode (Irigoien et al. 2005). Whether this is a revolt (sensu Holling 2001) or a gap in the causal fabric, the inconvenient truth is that this is not simply an epistemic shortcoming but an ontological reality after all (Ulanowicz 2009). A reality that involves chance, feedback, and history; a reality that results in non-random yet essentially indeterminate outcomes.

O QUANTA QUALIA

We have seen how one might approach the complexity of ecological systems; but not all facts are observable; thus, we become unsure of the path to truth. If we stretch our macroscope to its transcendent limit, we would perhaps also see α, *r, K,* and Ω in Stephen Gould's memorable exposition of the pictorial frontispiece in Thomas Burnet's *Telluris theoria sacra*. There lies time's arrow in the context of time's cycle, a circular arrangement of globes beginning (α) and ending (Ω) in immanence, a complex set of correspondences between our past and future (Gould 1987). We would not have to profess, as they did in Nicaea in 325 that 'We acknowledge one Baptism for the remission of sins, And we look for the Resurrection of the dead, And the life of the world to come'. Instead, we acknowledge one magisterium (domain of teaching) for the remission of dianoetic despair, and we look for the renewal (α) of the destroyed (Ω), and the life of the world in adaptive cycles.

We travelled to the Canadian arctic. Everywhere we looked in the ocean, we experienced a quantum of reality drawn from dynamic mechanical linkages that propagate cause to effect; at the same time, we also perceived a quale of reality drawn from knowing that life is a process that is non-reversible and indeterminate. Each reality is whole in itself and we can move easily from one to the other, but it is their unification that we need to seek. Panentheism may or may not be a panacea for the pandemonium of panarctic panarchy, but it does not take the reminder of a still small voice for us to cherish the quanta and qualia of it all. Look far over the sky at the wind, stare deep into the ocean at the phytoplankton, gaze openly at your fellow travellers: up, down and all around. Triad of Trinity, or triad of mind, matter and purpose?

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