Chapter 4

Paradigmatic Transformation across the Disciplines; Snapshots of an Emerging Complexity Informed Approach to Progress, Evolution and Sustainability

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A new global societal paradigm is emerging. This is a paradigm informed by complexity. It is one which recognises an irreducible and dialectical dualism at many levels of reality, that is, not a reductionist 'either-or' dualism but one characterised by agonistic (opposing yet complimentary) tendencies (Morin, 2008; Ulanowicz, 2009a). At its heart it is a paradigm 'not of another metanarrative but of a *context* for a plurality of little narratives to coexist which offers hope for the future' (Montuori, 2012, p.38). While still at the margins compared with the dominant 'paradigm of disjunction/reduction/simplification' (Morin, 2008, p.29) that has characterised modernity, its effects are pervasive right across the disciplines, and beyond. The term paradigm is used here in a way which concurs with Kuhn's notion of paradigms as across the board 'community-based activities' (Kuhn, 1962, p.179). The result is that not just one field or discipline is transformed, but a great many domains are affected concurrently, and effect one another both tangentially and recursively.

This development has socio-historical resonance. It occurs when a whole knowledge/societal 'ecosystem' undergoes radical transformation, such as for example, through what was known as the Axial age, or most recently the neo-Cartesian era of reductionist Modernity which has dominated Western (now globalised) society for the past four centuries. Such paradigmatic changes operate at the level of whole civilizational transformation, impacting across all branches of coherent knowledge and received wisdom. Thus simultaneous developments are apparent in physics and mathematics, in the biological sciences, in economics and in the social sciences.

The result is a contemporary pre-paradigmatic 'great transformation' pointing to the emergence of what Morin would characterise as a new paradigm of 'complex thought' (Morin, 2008, p.5). This entails a series of new conceptions across the disciplines ranging from for example, the trust-control nexus in organisational management (Möllering, 2005) to dealing with risk in socio-technical systems (Perrow, 1984). This chapter will consider some disciplinary approaches to progress and sustainability through this agonistic dualism, hence demonstrating a broader set of consistencies across diverse disciplinary traditions which point to a deeper ontological basis or a new metaphysics which would in turn help support a claim for the emergence of a complexity informed 'process' paradigm.

One contemporary manifestation of this tradition is found in the guise of (integrative) transdisciplinarity. Such an approach is perhaps the only rational response of science – in all its physical, natural and social guises – to 20th century developments in quantum physics, Gödelian uncertainty and the process worldview entailed by the second law of thermodynamics. Four disciplinary examples from disparate areas will be considered through this chapter. These range from the hard scientific to the socio-technical and from the socio-economic to the philosophical and transcendent. Specifically, these relate respectively to:

- Chemical phase equilibrium thermodynamics
- Electrical power generation and transmission/distribution
- Management and leadership
- Influence of process thought and integrative thinking on theology

Process through the Second Law of Thermodynamics

> Thermodynamics provides the underpinnings for an understanding not only of life's chemical genesis, but of its present function, from Amazon ecosystems to the global economy. Not only is life not removed from the thermodynamic imperative of the second law, it is the most impressive and awe-inspiring manifestation.
>
> Schneider and Sagan (2005, p.71)

> *'The entropy of the universe increases with any spontaneous process'.*
>
> Second Law of Thermodynamics

If entropy might be considered as a measure of the extent of 'spread-outedness' of energy (and also by extension, matter as its equivalent), then it is clear from the second law that there is a universal tendency for energy to *flow* from being concentrated to becoming diffuse over time. *Time* is therefore a property congruent with transformational *process* (in a manner consistent with Heraclitean notions of change and reality), as the second law (Prigogine's (1997, p.1) 'arrow of time') imparts irreversible directionality on cosmic evolution. Concentrated or directed energy (a barrel of oil for example, or a charged battery) is thus laden with what is called 'free energy' and it thus has *value* as it has the *potential* to do useful work while dissipating the energy towards a higher entropy state. The second law thus imbues the universe with a general sense of purpose or directionality, and as Coffman and Mikulecky (2012, p.43) point out, this construct reimbues science with the classical Greek concept of *telos* (purpose). The 'goal' ahead of the universe therefore is to put available (low entropy, concentrated) free energy to use by dissipating it over time, in a process which also involves ongoing adaptive change and creativity and the emergence of reciprocal self-organizing complexity (Alexander, 2011). It is a significant fact of reality that coinciding with this running down/dissipation there is a corresponding (and necessary) complexification going on; 'In any real process, it is impossible to dissipate a set amount of energy in finite time without creating any structures in the process' (Ulanowicz, 1997, p.147). This entails literally creating order (and expending energy in the process) out of chaos (Schrödinger, 1944; Schneider and Kay, 1994). By implication, the specific rate at which a system dissipates energy (W/kg) can be taken as a proxy measure of its complexity. By this measure Chaisson (2010) maps out a 'big' historical timeline demonstrating a hierarchy of increasing complexity from particulate, galactic, stellar and planetary through to chemical and biological systems, to the human brain (the most complex natural entity known by this measure) and hence to cultural and technical artefacts and systems.

There is thus an ongoing agonistic 'dance' being entertained invoking increased complexification on one hand and the corresponding (and necessary) dissipation of available free energy in the universe on the other, suggestive of the 'dual nature of entropy' (Ulamowicz, 2009b, p.85). Developing ecosystems configure increasingly towards the right hand side of the 'window of vitality' (as described in Figure 3.1 of Chapter 3) and tend towards increased organisation and complexity when afforded additional energy and resources. Ulanowicz (2009b, p.93) speculates too that given the fact that increased universal entropy (dissipated energy) coincides with such increasing growth and ascendency, it may be that on a broader scale, the fate of the universe (or at least part(s) of it) might possibly be tied up with a construct of 'enduring equilibrial harmonies' rather than inevitable dissipation (heat death).

Chemical Phase Equilibrium Thermodynamics

The agonistic tendencies inherent in entropy and the second law which point towards organisation and disorder respectively can be demonstrated by the following example from chemical phase equilibrium thermodynamics. This is a threshold concept in chemical engineering (Byrne and Fitzpatrick, 2009) which is used to determine the ease with which components may be separated from each other on the basis of relative volatility, hence facilitating the design of suitable unit operations to achieve this e.g. distillation columns. This example resides of course within the broader and more significant area of nonequilibrium thermodynamics (which incorporates and facilitates emergence, evolution, life and society). The second law can be formally written in the following terms:

$$\Delta s_{\text{UNIVERSE}} = \Delta s_{\text{SYSTEM}} + \Delta s_{\text{SURROUNDS}} \geq 0$$

That is, the change in entropy (Δs) of the universe over any given duration, which comprises the sum of the change in entropy experienced by some arbitrarily defined system plus the change in entropy experienced by all that is without the system (i.e. the surrounds), must be greater than or equal to zero – the entropy of the universe can thus only ever increase. Within this construct however, it is possible for the local entropy of the system to *decrease* for example, but only so long as the entropy of the surrounds increase by a greater magnitude (Prigogine and Stengers, 1984). In fact, this happens regularly: increased system ascendency (defined as the product of organisational structure and dissipative capacity (Ulanowicz, 2009a, p.87) associated with the development of a growing living organism, or ecosystem, or city, or the manufacture of a technological device, are all associated with decreased local (i.e. system) entropy. However, this is always accompanied by dissipation of energy, and hence increased entropy into the surrounds, which is of greater magnitude. From an environmental perspective, this is problematic once certain thresholds (carrying capacities) are surpassed as it manifests itself as environmental degradation (Wessels, 2006, p.51).

An identical way of writing out the second law in computable form (where all parameters relate directly to the system) is in terms of what is called the Gibbs free energy, G (J/mol):

$$G = H - Ts$$

Here, H refers to system molar enthalpy (J/mol), s is system entropy (J/molK) and T is the system temperature (K). This is a useful equation since at any given system temperature (T) and pressure (P), G will be minimised (at its lowest) whenever thermodynamic equilibrium conditions exist. (This relates to the lowest point of the curve representing G (i.e. at $\Delta G=0$) on Figure 4.1 (see discussion to follow)).

This is best demonstrated with an example, of the simple closed system equilibrium kind. Suppose we take some pure compound (let's call it A) and suppose this compound is placed within a closed container at some fixed temperature (T) and pressure (P). Now it is conceivable that temperature T is below the boiling point for species A at the container pressure but above its freezing point. The compound will therefore principally exist as a liquid in the container. However, even when species are considerably below their boiling points, a certain proportion of molecules will still distribute between the liquid phase and the vapour phase when at equilibrium. This is familiar to anyone who opens a bottle of perfume – even though the volatile perfume remains below its boiling point a significant number of molecules will go from the liquid phase to the vapour phase and the scent of perfume will soon be evident in the vicinity. A similar effect occurs when water evaporates over time, even in a 'closed' system of a room.

What then is making this happen? What 'force' causes a significant number of perfume or water or petrol molecules, well below their boiling point, to leave the liquid phase (let's call it x) and for these molecules to ultimately distribute themselves between the liquid phase (x) and vapour phase (y) in a closed system? Well, it relates back to the second law and the entropic tendency to diffuse. The second law states that energy tends to become diffuse with any spontaneous process. Since the molecules of A represent loci of energy, there is thus a natural tendency for molecules in any confined space or container (i.e. closed system) to spread out as much as they can and thus increase the system entropy or 'spread-outedness'. The best way of doing this is by filling the whole container and (assuming it is not completely filled of liquid to start with) this means that the molecules would distribute in a way which facilitates them taking up as much space as possible by distributing among respective liquid and vapour phases (and thus increasing system entropy).

In a liquid-vapour system the system entropy is comparatively at its lowest when all the molecules are in the liquid state. There is then a rise in entropy as the first molecule goes from the liquid to the vapour state, and entropy continues to rise as more and more molecules transfer into the vapour state. However, the increase in entropy is not linear; the first million molecules (say) to transfer from the liquid to vapour state will cause a certain increase in system entropy (or 'spread-outedness', or disorder), but a million molecules entering the vapour phase which already holds a trillion molecules (say) will have a lower *relative* impact in terms of adding to disorder or entropy. There is thus a fall off in the rise of entropy as the ratio of molecules of A in the vapour to liquid phase (y_A/x_A) increases (or similarly as the number of molecules in the vapour phase relative to the total number of molecules in the system ($[y_A/(x_{A+}y_A)]$) increases). In the Gibb's free energy equation this tendency towards entropic disorder is captured by the 'Ts' term, where system entropy (s) is multiplied by the (constant) system temperature (T). (Figure 4.1 provides a graphical representation how Ts actually changes with an increasing ratio of molecules in the vapour to liquid phase as evaporation proceeds (going from left to right).

But if there is a universal tendency for energy to spread out and dissipate, then why don't all molecules do this and transfer into the gas phase (and hence maximise entropy)? Indeed, why don't all liquids and solids do likewise, and hence why does solid matter, or indeed why do ourselves exist at all (or at least in anything other than vapour form)? Of course, as behoves the 'dual nature of entropy' (Ulanowicz, 2009b, p.85), there is an agonistic i.e. opposite, though necessary 'force' across the universe which draws molecules closer together. This is represented by the various forces of attraction between entities – essentially gravitational, e.g. inter and intra-molecular, etc. which act as the glue that helps build complexity. The bonds that hold solids together are greater than those between a liquid of the same species which in turn are greater than the intermolecular forces between gas molecules. Thus in order to be 'released' from a liquid to a gas for example, the difference in intermolecular attractive forces between liquids and those between gas molecules must be overcome. This aggregate amount of energy is known as the heat of vaporization. Thus a certain quantifiable amount of energy is required to release one molecule from the liquid state and into the vapour state. Twice that amount will be required for two molecules to be released and so on. Thus the energy (or enthalpy, H) required is directly proportional to the amount of molecules which go from liquid to vapour state and H increases linearly as more and more molecules go from liquid to vapour.

This too is represented in Figure 4.1 and is of course the other term, H in the Gibb's equation which, since it opposes the other tendency (towards entropic dispersion), is represented by an opposing sign (positive, as opposed to negative for Ts). The sum of these two opposing terms equals the Gibb's free energy (as represented by the equation G = H - Ts). The curved line represented by G in Figure 4.1 therefore is a graphical representation of the above equation, obtained by subtracting the (molar energy value of the) Ts curve (which represents increased entropy) from the (corresponding value on the) H line (representing the (agonistic) attractive organisational forces) along each point on the x axis. Thermodynamic equilibrium in this closed system is by definition, represented by the lowest point in the curve G (which mathematically corresponds to $\Delta G=0$, and which is equivalent to the maximum entropy – as per the second law), which indicates the ultimate steady state distribution of molecules between the liquid (y) and vapour (x) phases in this system at equilibrium conditions. In practical terms the distribution of molecules between vapour and liquid at equilibrium ($[y_A/(x_{A+}y_A)]_{min}$) can be ascertained by reading the abscissa (by extending a perpendicular from the minimum up to the x-axis and then reading off the x-axis). If a closed system has a distribution of molecules between vapour and liquid which represents a point either side of the minimum, then it will tend towards equilibrium over time and the molecules will aggregately redistribute in the required ratio (towards $[y_A/(x_{A+}y_A)]_{min}$) just like a ball will roll down a valley until it eventually settles at the bottom. Thus a situation where a very high concentration of molecules are in the liquid phase relative to the vapour phase (just as the cap is taken off the perfume bottle in a closed room) could dictate that the system is to the left of the minimum point on the curve G (the Gibbs free energy would be above its minimum), and there would hence be a driving force which would facilitate molecules evaporating until an equilibrium distribution of molecules between vapour and liquid phases had been achieved.

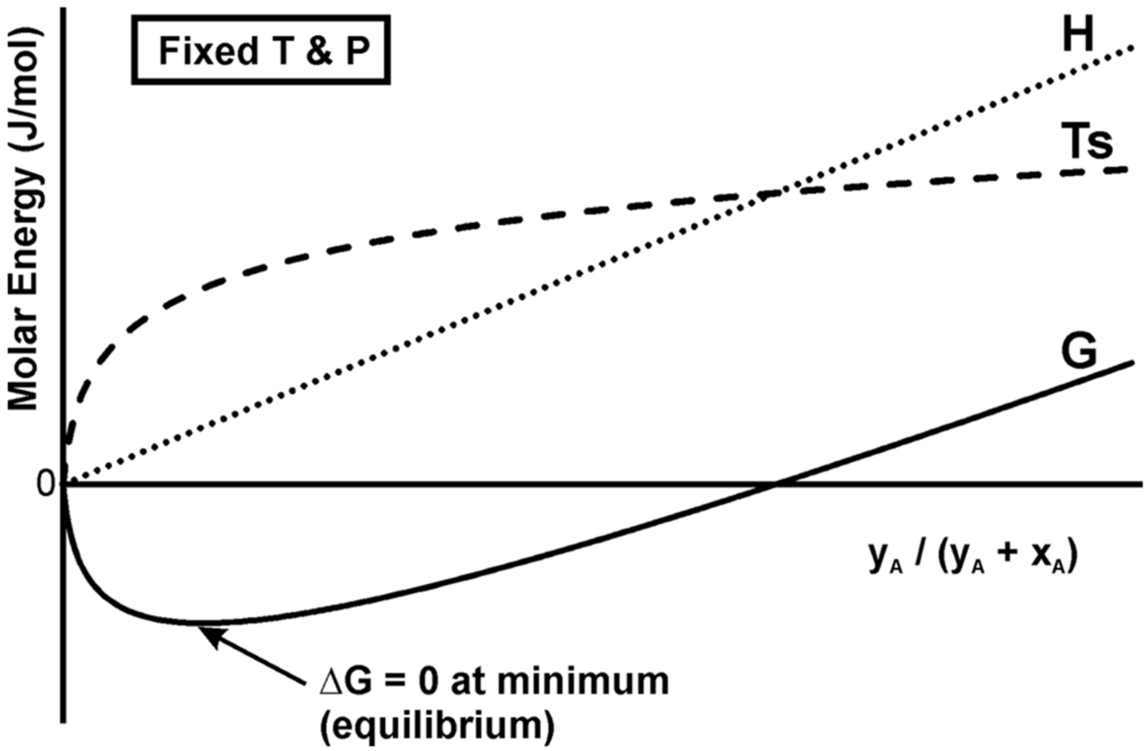

Figure 4.1 Graphical representation of Gibbs free energy (G = H − Ts) to determine thermodynamic equilibrium

More generally, the point at which the Gibb's free energy is minimised is identical to the point which facilitates the maximum entropy of the universe, as ordained by the second law, though this of course does not require that the entropy of the system *alone* be maximised, only that of the combined system *plus* surrounds. Hence the second law allows that the *local* entropy of the system can be reduced, which in turn facilitates increased local organisation and complexification. Indeed as per the earlier suggestion around it being impossible to dissipate substantial amounts of energy without creating structures (Ulanowicz, 1997), it positively promotes it.

The upshot of this dialectic reality, informed by the second law (in the form of the Gibb's free energy equation) is that the formation of states which are more complex and have lower entropic values than gases, such as liquids and solids, are not just allowed but are unsurprising. Fundamental agonistic tendencies thus facilitate the creation and sustenance of the universe as we know it!

Electrical Power Generation and Transmission/Distribution

The generation, transmission and distribution of electrical energy represents a complex socio-technical system which has grown over the past century to the extent that 'electric power grids are among the most complex networks ever made' (Amin, 2011, p.548). The fact that supply and demand must always be synchronous only adds to their complexity. The traditional model has involved a top down centrally controlled generation system comprising a vast transmission and distribution network supplied by a small number of very large power generation sources. It could therefore be characterised as having a large degree of ascendency by Ulanowicz's model (see Figure 3.1 in Chapter 3) with a correspondingly high level of potential fragility. It has also been pointed out that from a growth in consumption/demand perspective, top down 'centralised systems can overshoot demand and produce too much energy at times of low usage', while top down centralised planning can have the effect of 'build[ing] out large capacity at very high costs' whereby there is then every incentive for 'the demand to grow into the supply' (Binns, et al. 2007, p.22). Moreover given the current structure of the grid, Pagani and Aiello (2013, p.2696) observe that 'the characterization of resilience is the main motivation for the studies involving complex network analysis and power grid', particularly if targeted through non-random attacks on particular system nodes. Twenty eight electrical network resilience analysis studies surveyed by Pagani and Aiello (2013) revealed a focus on issues around efficiency, robustness, reliability, sensitivity and connectivity loss. In this context, Binns, et al. (2007, p.67) have argued that:

> Energy policy in the EU is at a defining moment. Societies in the EU can keep on the current path and exacerbate the inefficiencies of the traditional power system. They can keep trying to fill the ever-widening energy gap between supply and demand while making piecemeal efforts to drastically mitigate climate change. Or, they can try something different and highly promising.

That 'something different and highly promising', Binns, et al. (2007) argue, amounts to a focus on both micro and community decentralised generation options over traditional centralised systems. Carley and Andrews (2012, p.114) would agree, suggesting that 'the current electricity generating regime is arguably approaching a critical tipping point at which it could either embrace a pathway toward a significant transformation to a more sustainable system, or more deeply entrench the existing regime'. Both these groups propose that what is required is not just the incorporation of renewable generation sources, but a new regime which involves an appreciable shift towards small scale micro-generation and community owned systems to *supplement* the existing top down model. This shift (to the left and back towards the 'window of vitality' on Ulanowicz's model (Figure 3.1 in Chapter 3), though not, it must be pointed out, to the extent that one would seek a model exclusively based on microgeneration, which would lack necessary ascendency), would have many inherent advantages, including greater local energy security, improved grid resilience, reliability, flexibility, greater connection between producer and user, increased local autonomy, reduced overall demand, better match between local supply and demand, reduced negative externalities (e.g. those living near get benefits of use), more diverse, equitable and local ownership of generation and distribution infrastructure, greater local buy-in, local cost savings and local job opportunities (Binns, et al. 2007; O'Brien and Hope, 2010; Amin, 2011; Carley and Andrews, 2012). It would also have the not inconsiderable effect of democratising energy production and consumption, while shifting the ownership and control relations around electricity towards less centralised and privatised or state-dominated electricity systems.

A study on future grid generation, transmission and distribution scenarios in Great Britian identified five models ranging from a top-down 'Big Transmission and Distribution' (Big T&D) model which is largely 'in line with current planned developments and trends', to a more transformative diffuse 'Microgrids' one (Ault, et al. 2008). Nevertheless, the latter scenario, while 'the transmission infrastructure still plays a key role in system operations, the utilisation of network capacity is relatively low, and the role of central generation is reduced' (Ault, et al. 2008, p.58). Modelling of the various scenarios purported to demonstrate for the 'microgrids' scenario 'significant demand reductions, over and above those delivered by efficiency improvements, resulting in a 26% reduction in total energy demand between 2000 and 2050 and a corresponding 71% reduction in total energy system carbon dioxide emissions (p.70). The corresponding figures for the Big T&D scenario, which most closely represents a 'business as usual' model with improved efficiencies and 'Big renewables', were a 5% increase in total energy demand and a 30% reduction in energy system CO_2 emissions over the same period (p.95). While it is unclear which model may actually be followed/chosen, the authors point out that 'an emphasis on large scale renewables and especially from offshore sources' in current UK government policy would tend to favour and reinforce the 'Big T&D' scenario as the most likely trajectory (p.110). This is not helped either by a lack of any policy support towards microgrids in the UK (Hoggett, 2014), a situation which is replicated more broadly internationally, and this situation is further entrenched by an energy industry who are hostile to microgeneration and who seek regulatory support in frustrating it (Binns, et al., 2007).

The 'optimum' configuration proposed by many experts again points towards a context dependent combination of the respective extremes represented by a top down centrally controlled system and a bottom up localised diffuse regime, in order to promote 'greater than sum' gains such as enhanced energy security, resilience, efficiency and sustainability (Amin, 2011). For example, Carley and Andrews (2012, p.108) propose 'a 'sustainability electricity scale spectrum' composed of a combination of traditional macro-generation facilities with increased integration of micro-grid systems, distributed generation systems, micro-generation units, and end-user conservation and efficiency'. This would of course require a significant transition from existing structures towards a less ascendent system, from which would emerge significant social, environmental and local economic benefits. It would also of course both require and facilitate a transdisciplinary approach to an issue which traverses both energy supply and demand, specifically the technical/engineering and social/behavioural issues which impact recursively on decisions and practices in relation to electrical production, distribution and consumption.

Management and Leadership

There is recognition in the area of leadership and managing people of the need to strive to obtain a contingent and appropriate balance between respective agonistic tendencies of organisational 'control' and 'autonomy' as a means of driving organisational success and sustainability. This is what Montuori (2012, p.40) would call the '"complex" ideal type' of organisational structure. It requires that leadership be conceived of as going beyond a simple linear 'command and control' role that would 'hold conventional notions of top-down leadership, or who find conflict or loss of control uncomfortable' (Hill, et al. 2014a). This conflicts with the traditional reductionist management approach which would seek to covet the mirage of ever reduced risk and uncertainty through seeking organisational control and accountability. Hill, et al. (2014a) by contrast, characterise the role of leadership as one which can successfully navigate the 'fundamental tension, or paradox' that is involved in 'unleash[ing] individuals' talents, yet also harness[ing] all those diverse talents to yield a useful and cohesive result'. Once more echoing Ulanowicz's sustainability model (Figure 3.1 in Chapter 3), Hill, et al. (2014a) resolve the opposing tendencies of unleash (inchoateness) and harness (order) into six constituent paradoxes, namely: individual vs. collective identity, support vs. confrontation, learning and development vs. performance, improvisation vs. structure, patience vs. urgency and bottom-up vs. top-down. A pragmatic context dependent management/leadership style is therefore required amid an ongoing 'process of continuous recalibration' (Hill, et al. 2014a):

> The "right" position at any moment will depend on specific current circumstances. The goal will always be to take whatever positions enable the collaboration, experimentation, and integration necessary for innovation. Leaders who "live" on the Harness side will never fully unleash the "slices of genius" in their people; those who always stay on the Unleash side will have constant chaos and never solve any problems for the collective good.

Moreover, just as the 'window of vitality' offers a path to progress, sustainability and evolution via an emergent 'greater than the sum of the parts' trajectory as epitomised by Ulanowicz's ecological model (see Byrne, Chapter 3), a similar dynamic is evident in the area of leadership. In their corresponding book, Hill, et al. (2014b) develop this idea with the transdisciplinary notion of seeking an (emergent, creative) integrative approach rather than a simple linear compromise. They describe three ways to resolve problems or conflict. The first is where the dominant faction simply imposes a 'solution'. The second approach envisages that the two parties can find a compromise, through splitting the difference between opposing options and viewpoints. But (p.19):

> Unfortunately, domination or compromise often leads to less than satisfying solutions. The third way, integrating ideas – combining option A and option B to create something new, option C, that's better than A or B – tends to produce the most innovative solutions. Making integrative choices, which often combine ideas that once seemed in opposition, is what allows difference, conflict and learning to be embraced in the final solution. … So important is integrative decision making that innovative organizations and their leaders don't just allow it, they actively encourage it.

While this complexity informed thinking is featured in much contemporary management and leadership scholarship it is by no means unique or indeed novel. As far back as the 1920's the organisational management pioneer, Mary Parker Follett would urge leaders not just to forge a middle ground between 'an overbearing authority' and a 'dangerous *laissez-*

faire', but to exercise the context dependent 'authority of the situation' (Follett, 1933, cited in Graham, 1995, p.129). Follett saw the value in integrative approaches to problem solving, citing an example of a small reading room in the Harvard library where someone wanted the window open while she wanted it shut. An integrative solution was found whereby the window in a vacant adjacent room was opened. This didn't represent a (half way, open versus closed) compromise she points out, because both parties got what they wanted, whether that be fresh air or no cold breeze blowing directly upon them (Follett, 1929, cited in Graham, 1995, p.69). Her philosophy of emergent opportunity amid agonistic tension as it applies to organisational management was summed up as follows (Follett, 1929; cited in Graham, 1995, p.87).

> One test of business administration should be: is the organization such that both employers and employees, or co-managers, co-directors are stimulated to a reciprocal activity which will give more than mere adjustment, more than an equilibrium? Our outlook is narrowed, our activity is restricted, our chances of business success largely diminished when our thinking is constrained within the limits of what has been called an either-or situation. We should never allow ourselves to be bullied by an 'either-or'. There is often the possibility of something better than either of two given alternatives. Every one of us interested in any form of constructive work is looking for the plus values of our activity.

The above represents just some glimpses of the manifestation of complexity thinking over a reductionist approach to leadership and organisation. This is an approach which has particular resonance in contemporary tech business circles, characterised as they are by rapid evolution, creative disruption, global reach and ascendency. A prime exemplar of this approach is co-founder of animation design studio Pixar, Ed Catmull, who set out as his goal to build 'not just a successful company but a sustainable creative culture', while he recognised that in order to achieve this a reductionist approach of trying to close down uncertainty and risk through control would also haul the organisation beyond the 'window of vitality' and thus counterproductively suffocate creativity and emergent learning (Catmull and Wallace, 2014, p.xvi):

> I believe that managers must loosen the controls, not tighten them. They must accept risk; they must trust the people they work with and strive to clear the path for them. … Moreover, successful managers embrace the reality that their models may be wrong or incomplete. Only when we admit that we don't know can we ever hope to learn it.

Influence of Process Thought and Integrative Thinking on Theology

Process thought and process philosophy take a Heraclitean view of integrative reality to foster a perspective of theology which envisages itself as a continually evolving endeavour which both embraces and is nourished by contemporary (and evolving) conceptions of science, evolution and cosmic history. Such a theology strives to cohere with contemporary scientific reality in a way that seeks to both draw from and feed into broader (i.e. post reductionist, integrative, process and complexity) conceptions of science, while exhibiting an ethic of care for the natural as well as the human world (Cobb, 1995; Edwards, 2006). Writing from within the Jewish tradition, Rabbi Bradley Artson (2013, p.xiv) describes it thus:

> Every creature is a resilient pattern of interlocking energy, each in a developing process of becoming. Because *becoming* is concrete and real, and *being* is only a logical abstraction, the distillation of becoming in pure thought, Process Thought focusses on

> becoming as the central mode of every creature, of all creation, and indeed of the Creator as well. The universe is recognised as a series of interacting, recurrent energy patterns, but not one that endlessly loops in the same repetitive patterns. Instead the surprising miracle of our universe is that it seems to generate novelty with each new moment of continuing creation. New stars, new galaxies, and new elements, combine and create new possibilities. At least once, a galaxy with sufficient stability and diversity produced at least one solar system with at least one planet on which the slow and gradual evolution of self-conscious life could – and indeed did – emerge.

Process thought and its resultant understandings would reject the Cartesian (antagonistic) dualism that reductionist models of both science and religion ascribe to (Delio, 2013, p.10), specifically the separate body-mind, matter-spiritual or physical-psychic duality that has characterised the paradigm of modernity. Reductionism's ground rules involve laying out these two domains as being entirely separate, and the resultant battles are then fought over the existence and/or the relevance of the latter (spiritual/psychic) domain. Indeed, in rejecting this separate and antagonistic Cartesian duality, a process thought informed theology would strive to disarm the need for interminable arguments invoked by a 'dualistic conception of "this world" and some "other world" – of life on earth and life in heaven above, of nature and supernature' (Kaufman, 2006, p.28). Materialist conceptions of science and reality driven by deterministic mechanisms (as opposed to open 'propensities' involving complex contingencies (Ulanowicz, 2006)) would require each cause and effect mechanism to be explained by some other mechanism *ad infinitum*, thus ultimately requiring some final efficient cause, which ironically 'reinforces the rational cognitive "need" for the supernatural' (Coffman and Mikulecky, 2012, p.83), or alternatively, the need to argue against it. Process and integrative informed conceptions of theology would however consider it impossible to envisage the whole of reality through reductionist materialism alone, but would extend it to one which would conceive of the 'sacred within the secular' (Dinges and Delio, 2014, p.179). It is in this vein that Pope Francis, while admitting that Chritians have not always given appropriate consideration to it, that 'the life of the spirit is not dissociated from the body or from nature or from worldly realities, but lived in and with them, in communion with all that surrounds us' (Francis, 2015a, para. 216). Such a conception would therefore envisage divine presence, and hence the potential for creative evolution, 'all the way down' in a way that seeks to facilitate an integrative middle ground between the material and the spiritual: 'The doctrine of nondualism counterposes that between contraries, as opposed to contradictories, there can and should exist a middle-ground position that mediates between them.' (Bracken, 2006, p.26).

This opens the possibility too of avoiding the discrete and rigid demarcation between the non-living and the living, but rather seeing them as respectively representing a progressively increasing and emergent manifestation of the psychic-spiritual-conscious domain, culminating in the self-reflecting consciousness of humankind. Thomas Berry characterises it in the following terms, placing the most recent neo-Cartesian period of reductionist modernity in broader historical context while aligning what he characterises as the spiritual domain with a cosmic temporal trend towards increased consciousness (Berry, 2009, p.29):

> The evolutionary process of the universe has from the beginning a psychic-spiritual as well as a material-physical aspect. There is no moment of transition from the material to the psychic or the spiritual. The sequence of development is the progressive articulation of the more spiritual or numinous aspects of the process. If, for a period, this story was told simply in its physical aspect to the neglect of the psychic aspect, this is no longer adequate. The period of preoccupation with quantitative material processes

> seems to have been necessary for penetrating the deeper structures and functioning of the universe. But the unfolding of the universe from lesser to greater complexity and consciousness is now widely understood. … [thus] the human is by definition that being in whom the universe reflects on and celebrates itself in conscious self-awareness.

Contemporary cosmology understands a sequence of developments around the emergence of matter as a *process* resulting from early subtle asymmetries in an initial homogenous non-material (radiation energy only) universe alongside various feedbacks (Chaisson, 2009), while a similar sequence of events (i.e. a cycle of autocatalytic positive feedbacks followed by the emergence of organisms) are thought to be behind ecological evolutionary development (Ulanowicz, 2007). This, Ulanowicz (2007, p.49) suggests, inverts 'the Enlightenment message that the unchanging (dead) material world (and its attendant eternal laws) preceded any living forms', since (Ulanowicz, 2007, p.50, citing Salthe, 1993) as an emergent process, cosmic evolutionary development entails that 'some vague precursors of the subsequent stage possibly exist within the antecedent realm.' Ulanowicz (2007, p.50) thereby surmises [emphasis added]:

> We thus come to appreciate how the yawning disparity between dead matter and living forms can be bridged simply by shifting our focus toward the *developmental process* that preceded and gave rise to both. In this framework the appearance of life was no more exceptional than was the appearance of matter. The facts that matter became more highly defined before life appeared and that all natural life forms require a material substrate do not imply a superior position for matter in any ontological hierarchy.

Reflecting on how the theology of Berry was influenced by the Jesuit paleontologist Teilhard de Chardin, Vanin (2011, p.186) considers

> … the idea that the universe has both a psychic and a physical character. The implication is that if there is human conciousness, and if humans have evolved from the Earth, then some kind of consciousness has been present in the proces of evolution from the beginning. Matter is not dead or inert; it is a numinous reality, a reality with both physical and spiritual dimensions. Conciousness is intrinsic to life-forms and links life-forms to each other. There are various forms of conciousness; in the human conciousness is reflective.

There is in this cosmology a greater understanding of the deep connections and symbiosis between life (moreover human life) and the surrounding (both animante and inanimate) world from which it both feeds and contributes. Indigenous and aboriginal peoples of North America for example shared this belief, as they considered that (Deloria, 2003, p.171):

> Human beings were an integral part of the natural world and in death they contributed their bodies to become the dust that nourished the plants and animals that had fed people during their lifetime. Because people saw the tribal community and the family as a continuing unity regardless of circumstance, death became simply another transitional event in a much longer scheme of life.

Emergent creativity over external Creator

Residing contingently between (deterministic) control and (random) chaos through Teilhard's 'groping … directed chance' (Teilhard de Chardin, 1959, p.110) or Ulanowicz's Popperian ecological 'propensities' (Ulanowicz, 2006, 2009a, citing Popper, 1982, 1990) lies the emergent property of *creativity* (as cited in the previous section on management). The then Harvard theologian Gordon Kaufman proposed that 'serendipitous creativity', which can facilitate both radical novelty and evolution, could act as an appropriate metaphor for God (Kaufman, 2004, p.53). This he characterises as 'the ongoing coming into being of the novel and the transformative … no longer lodged in the person-agent operating in the world from beyond; it is manifest in the created order, from the Big Bang all the way down to and including the present.' (Kaufman, 2006, p.28). This concept coheres with that of theoretical complexity biologist Stuart Kauffman who, coming from a secular scientific perspective, arrives at a remarkably similar conclusion. In *Reinventing the Sacred: A New View of Science, Reason, and Religion,* Kauffman considers that in light of the 'ceaseless creativity in the natural universe, biosphere and human cultures', which is at once 'stunning, awesome and worthy of reverence', the most reasonable response to adequately describe this would be through 'the word God meaning that God is the natural creativity in the universe' (Kauffman, 2010, pp.xi, 284).

Jesuit theologian Joseph Bracken (2006, p.27) promotes a similar notion of creativity, describing it as 'what makes us (and indeed all of creation) godlike', and thus interprets creativity as something which results from a divine 'cosmic process in which novelty or spontaneity is present in varying degrees at all levels of existence and activity.' He notes however that the price of creativity is that it is also 'the root cause of the destructive and even demonic features of this world' (p.27), thus facilitating a good-evil dialectic to overlay the constructive-destructive, ascendent-disordering agonistic pairings.

Developing this theme, Teilhard de Chardin recognised the universal agonistic tendencies of entropy and gravitation as described by contemporary physics (and as outlined earlier in the context of chemical equilibrium thermodynamics) as manifestations of two 'energies'; an 'outside' one which is manifested as the universal tendency towards entropic disorder, and an 'inside' tendency which tends to draw matter towards complexification. The latter tendency towards attraction has facilitated the historical cosmic development of progressively: elements, compounds, life, (animal) consciousness and ultimately human reflective self-consciousness, with all its attendant emergent consequences, including cultural society, technological ascendency and the earth's thinking envelope (the 'noosphere', as epitomised today by the many features of connected globalisation, including for example, the world wide web) (Teilhard de Chardin, 1959; Haughey, 2014, p.205).

A theology informed by process thought may align the disordering effects of entropy too with the concepts of evil, pain and destruction, which particularly when viewed as a necessary and natural prerequisite for growth, complexification and creative evolution, can be viewed as a wholly necessary infliction and a 'means of transformation' (Delio, 2011, p.80), since ultimately 'suffering, pain, and death are part of an evolutionary universe' (Delio, 2011, p.40) though one in which God can also be seen to work (Hefner, 1984), and which ultimately may have redemptive aspects (Berry, 2009, p.33)

> Our sense of entropy in the unfolding universe gives us a basis for appreciating sacrifice as a primary necessity in activating the more advanced modes of being. The first generation of stars by their self-immolation in supernova explosions shape the elements for making the planet Earth and bringing forth life and consciousness.

Moroever, as Haught puts it, 'an originally perfect world would be a world without suffering. But it would also be a world without a future' since this would imply determinisitic constraint, so that all actions 'including human actions would be determined from the very start to be just what they are. There would be no indeterminacy or contingency' (Haught, 2006, p.190)

The universal tendency towards increased entropic disorder is of course opposed by the aforementioned dialectical tendency towards increased ascendency. Teilhard viewed this complexifying tendency as a manifestation of immanent divine 'spirit' (Haughey, 2014, p.205) and the 'attractive influence' which God uses to create (Delio, 2011, p.80).

This universal attractive tendency may also ultimately be seen to manifest itself as the social phenomenon of love (Peirce, 1940; Teilhard de Chardin, 1959), more broadly interpreted as a universal 'propensity to unite' (Teilhard de Chardin, 1959, p.264) and 'the dynamic principle at work in cosmic evolution' (Bracken, 2006, p.117). It thus acts as a sort of cosmic attractor, one 'which works through persuasion, not coercion' (Bracken, 2006, p.95), and which can ultimately draw humanity together, effectively 'an energizing force that draws together and unites' (Delio, 2011, p.86). It has thus been considered as 'a unifying, integrating, harmonizing, creative energy or power' which can ultimately be realised more specifically (or analogously) in the respective worlds of the physical (e.g. as gravitation, chemical affinity, magnetism), the organic (gregariousness, mutual aid, cooperation) and the psychosocial (conscious love, sympathy, friendship, solidarity) (Sorokin, 2002, p.6). Love is thus considered as a sort of final cause or underlying driver of both community and communion, the latter being among the three basic characteristics of the universe as proposed by Berry (the others being differentiation (diversity) and subjectivity (Vanin, 2011, p.191)). It is therefore modernity's singular one eyed focus on objectivity and separation that, Berry contends, prevents us from recognising that in fact 'the universe is a communion of subjects, not a collection of objects', and he thus opines that 'the devastation of the planet can be seen as a direct consequence of the loss of this capacity' (Berry, 2006, pp.17-18). Pope Francis, following the tradition of his namesake saint, promotes the idea of love as underpinning 'universal communion' so as to facilitate interlinking the ecological and the social while emphasizing a deep, familial connection between humans and the world around (both living and non-living): 'Everything is connected. Concern for the environment thus needs to be joined to a sincere love for our fellow human beings and an unwavering commitment to resolving the problems of society. Moreover, when our hearts are authentically open to universal communion, this sense of fraternity excludes nothing and no one.' (Francis, 2015a, para. 91)

Henri Bergson's notion of 'élan vital' (Bergson, 1911, p.43) also picks up on this idea of a self organising driver towards increased complexity and life. Bergson's process view of emergent creative evolution influenced both Teilhard de Chardin and Alfred North Whitehead, the mathematician and philosopher most closely associated with the origins of both process philosophy and theology, as articulated through his defining philosophical publication *Process and Reality* (Whitehead, 1929).

Integrative, complexity informed approaches towards science and process reality can facilitate the opening up of an easy and productive common ground between atheists, agnostics and secular humanists and adherents of various religious creeds or those who would embrace the spiritual and transcendent in a way which would neither be rational nor conscionable to anyone who'd look through the respective 'lens of fundamentalism' (Ulanowicz, 2009c, p.132) that a reductionist paradigm facilitates. These conceptions have been posited within what has been called a 'new spirituality', an 'eclectic, pluralistic and holistic' worldview which is but 'one element of a paradigmatic cultural transition' (Dinges and Delio, p.170), or in Thomas Berry's 'New Story' of the universe, 'a coherent evolutionary story that would draw together science and religion in an integrated manner' (Tucker and Grim, 2014, p.11). It thus transcends many traditions, not just across the broad Judaeo-Christian heritage, but also resonates with numerous other faith (and secular and non-faith) traditions and philosophies across an innumerable range of global and historic traditions and cultures.

Integrative Heraclitean inspired process thought can build also upon other insights and traditions (for example from the realm of classical neo-Platonist, Aristotelean and Thomist philosophical conceptions), in order to facilitate enriched insights and understandings. For example, it has been suggested that the classical concept of an eschatologically immutable God (no more than that of an immutable second law) might be squared with process thought by considering 'the analogies of non linear thermodynamics and [hence one might] conceive God as an *evolutionary attractor*' (Zycinski, 2005, p.96). Such an immutable evolutionary attractor would act as a 'creator', by drawing in/coaxing respective cosmic attractive tendencies (at all levels, including physical, chemical, biological, social) towards increased complexification. Thus this conception incorporates both the immutable (law[1]) and the ever changing/evolving (process) at once: 'God is to be found in the fact that a universe that is established through fixed, changeless propensities still generates novely all the time: new unprecedented things that did not previously exist.' (Artson, 2013, p.15). Or as Francis more succinctly characterised it: 'Before creating the world, God loved. Because God is love.' (Francis, 2015b). This precise though profuse statement encapsulates the dialectical nature of the relationship between the immutable (cosmic propensity for attraction; here characterised (in theological terms) as God's eternal love) and the ever-changing (ongoing evolutive creation). Similarly, Ulanowicz (2015) makes a case for integrative conciliation between respective traditions of classical and process philosophy by drawing analogy with hierarchy theory from the world of ecology and complexity.

All in all, theological scholarship informed by process thought and integrative approaches cohere with a transdisciplinary ethos as it envisages a 'plurality of explanatory levels' ahead of a more simplistic reductionism, which is no more than 'the manifestation of a *will* to control' and which would seek to promote 'the suppression of layered explanation … [in favour of] the arbitrary declaration that there can be only one level of explanation' (Haught, 2007, pp.143, 146). As Whitehead (1954, prologue) elegantly surmised: 'there are no whole truths; all truths are half-truths. It is trying to treat them as whole truths that plays the devil'.

Conclusion: Traces of a Common Thread

This chapter has sought to build on and demonstrate the *process* understanding of reality as epitomised by an emerging paradigm of (irreducible) complexity, essentially a 'scienza nuova' which would 'not destroy the classical alternatives … but the alternative terms become antagonistic, contradictory, and at the same time complementary at the heart of a more ample vision' (Morin, 2008, p.33). In doing this, it has considered a range of disciplinary areas where similar conclusions have been drawn with apparent independence about the importance of focusing on the actual *process* (rather than on prescribed deterministic system outcomes or outputs) and the resultant necessity for *contingent balance* between agonistic extremes in order to facilitate the emergence of evolving, sustainable and flourishing systems.

None of the four disciplinary examples described above are engaged to provide either an exhaustive or even a representative view of any of these respective fields, but instead aim to simply provide a series of snapshots or vignettes, which when placed contiguously alongside each another may possibly facilitate the recognition of an outline of a common overlapping ontological thread. That reality involves a world of agonistic dualities, engaged in an ongoing contingent 'dance' of progress which facilitates both the included middle and creative emergence. Indeed, it might only be expected therefore that, given the paradigm shifting ontological claims inherent in this framework, that analogous examples can be found and reflected amid various constructs, concepts and examples across virtually all disciplines and situations. Integrative models that have emerged contemporaneously, such as complexity theory, integral theory, critical realism and process philosophy provide corroborating evidence of this (Hedlund de Witt, 2013, p.36)

[1] e.g. The second law of thermodynamics or the universal tendency towards attraction (/love) which facilitates growth and complexification

This new complexity informed paradigm is what is envisaged by Morin's 'need for complex thought' (Morin, 2008, p.5), and as epitomised through the central column of Table 3.1 in Chapter 3. Such a paradigm may seek to facilitate the emergence of a new 'global ethic', one which can only be 'partially guided … because we cannot know all that will happen', but which 'must embrace diverse cultures, civilisations, and traditions that span the globe' and which 'must be of our own construction and choosing ... open to wise evolution [since] a rigid ethical totalitarianism can be as blinding as any other fundamentalism.' (Kauffman, 2010, p.273).

The essence to this approach is transdisciplinary. It is a place where 'integrate and transcend' replace 'divide and conquer'. The approach implies going *beyond* a pre-modern conception of reality which would revel in ignorance and superstition. It implies going *beyond* reductionism; the dominant modern conception of reality which would envisage uncovering some unique truth through reducible certainty and order, based on separate and opposing dualisms involving solid materialism and an effete mind. And it would go *beyond* a deconstructivist post modernism which would ultimately lead to a reduction to nihilistic relativism, selfish individualism, chronic pessimism and meaningless chaos. Instead this new paradigm, upon which we would construct a coherent 'new story', would both build upon and transcend previous wisdom and paradigms to concurrently capture the mystery, enchantment, awe and mythos of the pre-modern, the structure, reliability and ascendency of the modern, and the radical uncertainty and creativity of the postmodern. Only then might we be fit for purpose and equipped to meaningfully (and pragmatically) address the contemporary economic, social, ecological and ethical crises of our ever more complex society.

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