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Quantum Mechanics predicts evolutionary biology

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ABSTRACT

Nowhere are the shortcomings of conventional descriptive biology more evident than in the literature on Quantum Biology. In the on-going effort to apply Quantum Mechanics to evolutionary biology, merging Quantum Mechanics with the fundamentals of evolution as the First Principles of Physiology-namely negentropy, chemiosmosis and homeostasis-offers an authentic opportunity to understand how and why physics constitutes the basic principles of biology. Negentropy and chemiosmosis confer determinism on the unicell, whereas homeostasis constitutes Free Will because it offers a probabilistic range of physiologic set points. Similarly, on this basis several principles of Quantum Mechanics also apply directly to biology. The Pauli Exclusion Principle is both deterministic and probabilistic, whereas nonlocalization and the Heisenberg Uncertainty Principle are both probabilistic, providing the long-sought after ontologic and causal continuum from physics to biology and evolution as the holistic integration recognized as consciousness for the first time.

Contents

1. Introduction

Nowhere are the shortcomings of descriptive biology more evident than in the literature on “Quantum Biology” in the on-going effort to apply Quantum Mechanics (QM) to evolutionary biology (Sia et al., 2014). All of these endeavors have entailed the direct application of the principles of QM to the overt physiologic properties of biology as the product of evolution, rather than to the latter's ontologic origins and epistemologic causal mechanisms (Torday and Rehan, 2012). It is analagous with trying to understand the internal combustion engine of an automobile by applying physics to the wheels or transmission. However, as will be shown, the application of QM to the origin and causation of evolution at the cellular-molecular level reveals its mechanistic principles and offers the authentic opportunity to understand how and why physics constitutes the basics of biology (Torday and Miller, 2016a).

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2. Lipid control of calcium homeostasis as the history of vertebrates: a key to reductionist Quantum Mechanical approach

Reducing biology to QM offers complementary insights to the cellular-molecular level of biology (Torday and Rehan, 2012). In that vein, it has previously been shown (Fig. 1) that the direction and magnitude of genetic change can be seen as reciprocating internal and external responses to major stresses in the environment (Torday and Rehan, 2011). Throughout, these changes in genetics are in service to the epistatic balancing selection for calcium and lipid homeostasis (Torday and Rehan, 2012). Selection pressure for this mechanism began with the rise in carbon dioxide in the atmosphere (Berner, 1990), causing acidification of the oceans by the carbonic acid formed leaching calcium from the rock (Mitchell et al., 2010). Calcium is biologically toxic at high levels, so calcium channels appear to have evolved to regulate intracellular calcium (Case et al., 2007). Subsequently, the rise in atmospheric oxygen over the course of the Phanerozoic Era caused endoplasmic reticulum stress, causing calcium leak into the cytoplasm. In response, the cells formed or acquired peroxisomes, which utilize lipids to neutralize the deleterious effects of increased cytosolic intracellular calcium (De Duve, 1969). The predictive power of the Quantum Mechanical approach is expressed by the entraining of intracellular calcium, followed by its control through cell-cell interactions mediated by the coordinated effects of soluble growth factors and their receptors, perpetually referencing the First Principles of Physiology (Torday and Rehan, 2012).

3. Quantum Mechanics and origins and causation in biologic evolution

There is a consensus that the Laws of Physics determine all of the Natural Sciences (Birks, 1962), begging the question as to how physics has determined the principles of biology. A number of physicists have attempted to solve this riddle (Prigogine and Stengers, 1984; Polanyi, 1968; Schrodinger, 1944) but have failed, Prigogine, Stengers and Polanyi all concluding that biology is just too complicated. More recently, it has been claimed that life is actually simple (Torday, 2016a; Davies and Walker, 2016); we complicate it (Barrow and Tipler, 1988) from our narcissistic, self-serving perspective by reasoning after the fact (Bohm, 1980). Alternatively, it has been argued that there are homologies (in the sense of having common origins) between physics and biology. It is hypothesized that those homologies are due to their common origins in the explosion of the Singularity, otherwise referred to as the Big Bang (Singh, 2005). After all, Smolin (1997) has effectively argued that stellar evolution and Black Holes came about through Darwinian-like mechanisms. It is feasible that in the aftermath of the Big Bang, based on Newton's Third Law of Motion, an ‘equal and opposite reaction’ was met by self-referential self-organization, given that the only existing paradigm at the time was the Singularity. It was on that basis that chemistry (Valance, 2017) and biology (Torday and Miller, 2016a) may have come about. Although it can be argued that we cannot know the origins, initial conditions and causal mechanisms of evolution involved because we were not present when it happened, there are ways in which we can hypothesize how and why it occurred that are scientifically testable and refutable (Popper, 1963). Elsewhere, it has been argued that since lipids were critically important in the evolution of eukaryotes (Torday and Rehan, 2012), that they likely played a vital role in the origins and initial conditions of life based on the premise that evolution is pre-adaptive, or exaptive, or cooptional (Gould and Vrba, 1982) (Fig. 2). Lipids immersed in water may well have formed the basis for life since they accompanied the frozen snowball asteroids that formed the Earth's oceans (Deamer, 2017), and physicochemically spontaneously form micelles when immersed in water (Hamley, 2007), exhibiting hysteresis as molecular ‘memory’, able to recall their shape and size, which is necessary for evolution (Torday and Miller, 2016b). In the process of forming life, the lipid membranes that delimited the internal and external environments generated an ambiguity that became the nidus of life (Torday and Miller, 2017). Under these conditions, several homologs of Quantum Mechanics apply-namely the Pauli Exclusion Principle, non-localization, the Heisenberg Uncertainty

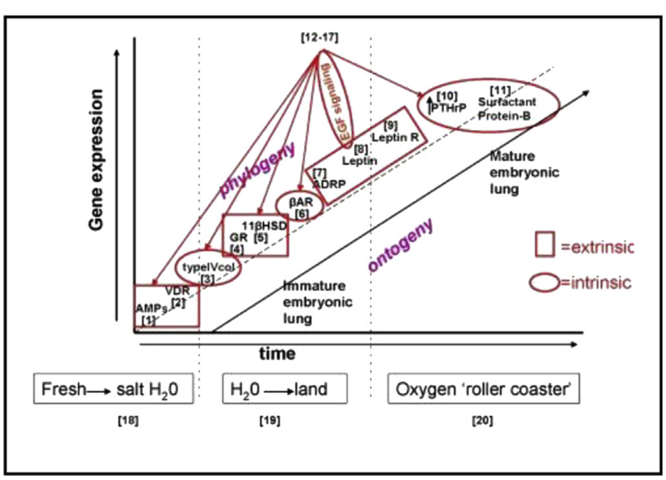

Fig. 1. Reciprocating extrinsic and intrinsic selection pressures for the genes of lung phylogeny and ontogeny. The effects of the extrinsic factors (salinity, land nutrients, and oxygen on the x-axis) on genes that determine the phylogeny and ontogeny of the mammalian lung alternate sequentially with the intrinsic genetic factors (y-axis), highlighted by the squares and circles, respectively. Steps 1–11 appear in the sequence they appear during phylogeny and ontogeny: (1) AMPs; (2) VDR; (3) type IV collagen; (4) GR; (5) 11bHSD; (6)bAR; (7)ADRP; (8) leptin; (9) leptin receptor; (10) PTHrP; and (11) SP-B. Steps 12–17 represent the pleiotropic effects of leptin on the EGF in oval signaling pathways integrating steps 1–6, 10, and 11. Steps 18–20 are major geologic epochs that have “driven” intrinsic lung evolution. (taken from Torday and Rehan, 2011).

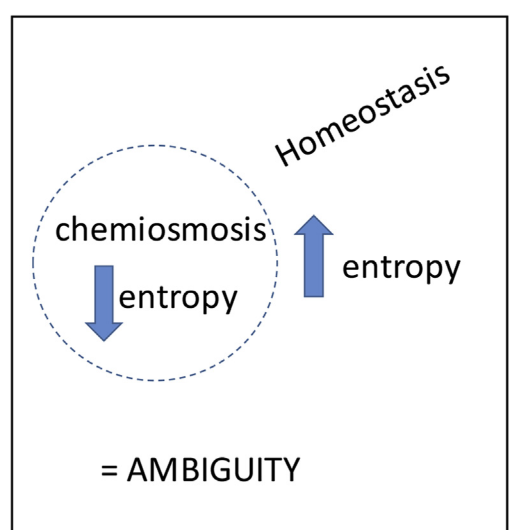

Fig. 2. Origins of Life. Lipids immersed in water formed micelles that delimited the internal and external ‘environments, allowing for negative entropy fueled by chemiosmosis within the cell, governed by homeostasis. The differential internal negative and external positive entropies generated the ambiguity of life.

Principle and Coherence (Krane, 1987). It has previously been proposed that there are First Principles of Physiology (Torday and Rehan, 2012) namely negentropy, chemiosmosis and homeostasis. The first two principles confer determinism on the unicell, whereas homeostasis confers Free Will because it offers a probabilistic range of potential set points (Golub et al., 2014). Thus, life exists between the boundaries of determinism and Free Will. Similarly, the Pauli Exclusion Principle also generates boundaries of determinism and Free Will in the physical realm since electron spin is ruled by its four quantum numbers, the first determining the second and third when filling the electron's quantum energy state (Krane, 1987). The fourth quantum number is time-dependent, offering a range of probabilistic electron energy levels, conferring Free Will in physical terms. So there is a precedent for determinism and Free Will in the formation of the elements that biology must comply with. Biology, in turn, mimics the Quantum Mechanical principles through homologies with the First Principles of Physiology.

Another feature of Quantum Mechanics is non-localization, the concept that the elements of the Cosmos are distributed throughout it (Bohm and Hiley, 1975). The same phenomenon holds true for biology in the form of pleiotropy (Torday, 2015). A gene can be found in many different tissues of the organism as a consequence of the mechanism of evolution, acting to identify genes in the organism's history that could be used in subsequent novel situations. The reiteration of this process under various environmental conditions constitutes the process of evolution (Torday and Rehan, 2012). Under physiologic stress, the same gene may be expressed in different tissues, but always referencing the original unicellular First Principles of Physiology, distributed throughout the organism in a non-localized manner (Torday, 2015). This distributive property is homologous (having the same origins) with the non-localization principle of Quantum Mechanics.

Life began as an ambiguity, the internal free energy or entropy of the cell being negative, in contrast to the positive entropy outside of the cell (Schrodinger, 1944). That differential entropy generated an ambiguity that acts as the on-going driver for the subsequent evolution of the organism over time both developmentally and phylogenetically. It forms a means of interfacing with the physical environment that exists in a perpetual ambiguous state of uncertainty, allowing the biologic system to effectively cope with the 'not knowing with certainty' characteristic of the Heisenberg Uncertainty Principle (Heisenberg, 1927). For example, Niels Bohr (Baggott, 2011) explained the seemingly paradoxical duality of light as both particle and wave being due to the differences in the way that it is observed, which is homologous with the ambiguity of the cell, coping with such paradoxes, as described above. So perhaps it is because physics, like life itself exists in a state of limbo regarding its surroundings that allows it to contend with and contemplate it, even at the QM level-*like 'devolves' like*.

4. Predictive value of a Quantum Mechanical approach to evolution

Prediction is necessary for 'hard' science (Popper, 1963). The following is a way of understanding biology mechanistically, allowing it to be interfaced with Quantum Mechanics functionally, revealing the common source of both as the Singularity/Big Bang.

5. The unicell-multicell approach predicts the iterative evolution of Niche construction: a holistic approach

In a previous publication (Torday, 2016b), the idea that the unicell was the first Niche Construction was hypothesized (Fig. 3). By internalizing the environment through endosymbiosis (Gray, 2017), physiologic principles evolved, made functional by compartmentalization (Gabaldón and Pittis, 2015). The subsequent communication between cells in support of metabolic cooperativity was manifested by the principle of Niche Construction, in combination with the inheritance of epigenetic marks, ultimately giving rise to larger and larger organismal communities. The widespread dissemination of these properties culminated in Gaia (Lovelock, 2009), the concept of the organic unity of the Earth. Over the course of the Earth's history, increases and decreases in oxygen (Berner et al., 2007) and carbon dioxide (Berner, 2003) in the atmosphere imposed physiologic stresses on life forms. By tracing the phenotypic changes in the gas exchanger under such regimens, the evolution of the mammalian lung was traced from its unicellular origins forward (Torday and Rehan, 2017).

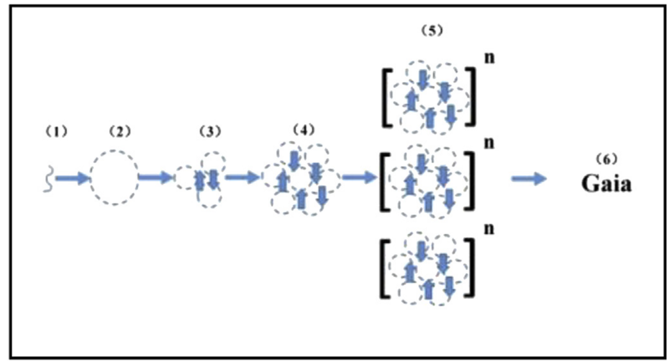

Fig. 3. Interaction between Niche Construction and Epigenetic Inheritance. (1) lipids in water spontaneously form micelles (2) delineating the internal niche construction of the protocell; (3) communication between cells promotes cell-cell communication; (4) metabolic cooperativity gives rise to multicellular organisms; (5) positive interactions between niche construction and inheritance of epigenetic marks fosters the formation of organismal communities; (6) the widespread interactions between niche construction and epigenetics ultimately gives rise to Gaia. Taken from Torday, 2016b.

6. The forward-direction of evolution predicts the role of Quantum Mechanics

Seen from its origins, evolution can literally be viewed homologously with Quantum Mechanics (QM). Reducing the process for the origin of life to its elements, expressed as the First Principles of Physiology (Torday and Rehan, 2012) offers the opportunity to see the one-to-one relationships between QM and physiology, much like Mendeleev's Periodic Table, reducing the Elements to their atomic numbers. Thus, QM can be applied directly to the process of evolution by considering its homologies with either the Pauli Exclusion Principle (Pauli, 1925), non-localization (Bohm and Hiley, 1975), or Heisenberg Uncertainty Principle (Heisenberg, 1949).

Pauli Exclusion Principle: is the quantum mechanical principle that no two electrons can have the same quantum state in a quantum system. This results from the filling of the four quanta of energy, with the first quantum determining the status of the second and third. The last quantum number is time-dependent, and is therefore probabilistic. As a result, the electron exists between the boundaries of determinism and probability. Similarly, the cell exists between the determinism of negentropy and chemiosmosis, and the probabilistic Free Will of homeostasis.

Non-Localization: describes the distribution of physical properties throughout the Cosmos. And because biology produces pleiotropic traits by acquiring the same gene over the course of its history under different environmental conditions, it also exhibits non-local behavior.

Heisenberg Uncertainty Principle: life began at the interface between negative internal and positive external entropy, generating an ambiguous condition. It is this 'uncertainty' that forms the basis for evolution as problem solving, conferring the capacity of biology to cope with Heisenberg's Principle.

7. Is there a homolog for Quantum coherence?

In physics, two wave sources are coherent when both their phase, frequency and waveform overlap. This is essentially what happens when a growth factor, endocrine hormone or neuroendocrine hormone stimulates its receptor, ultimately increasing calcium waves that transduce the signal to affect the physiology of the cell, tissue, organ and organism (Schuster et al., 2002).

8. The cytoskeleton as the homolog for self-organization and consciousness

Seen descriptively, the cytoskeleton is the superstructure of the cell. For example, actin fibers integrate many aspects of the cytoarchitecture. They anchor many proteins and enzymes, and keeps some membrane proteins anchored in specific sites within the plasma membrane, such as ion pumps and channels (De Loof, 2016).

Holistically the cytoskeleton functions to coordinate all of the functions of the cell in response to the environment, homeostatic, mitotic and meitotic alike. As such, it acts as the homolog for the 'consciousness' of the cell. The nature and origins of that property are referred to as the 'hard' problem (Harnad, 1998), which may be understood mechanistically as follows.

Hameroff and Penrose have reduced consciousness to the microtubules of the brain (Hameroff and Penrose, 2014), acting to transduce its activity through the cytoskeleton. This is yet another attempt to solve the 'hard' problem of consciousness based on descriptive biology. Seen from its diachronic origins (Sherrington, 1957), microtubules are elements of the cytoskeleton, which act as the transducers for all aspects of cell biology-homeostasis, mitogenesis and meiosis alike (Torday and Rehan, 2012). The significance of this relationship can be seen in experiments testing the effect of microgravity on cellular structure and function. When yeast are put in microgravity, for example, they lose their abilities to polarize and bud (Purevdorj-Gage et al., 2006), essentially placing the organism in suspended animation since polarization is necessary for calcium flux (Case et al., 2007), and budding is the way that yeast reproduce. Such effects are similar to those seen when lung and bone cells are put in microgravity (Torday, 2003), causing a loss of Parathyroid Hormone-related Protein (PTHrP) gene expression. PTHrP is a key pleiotropic gene that determines a wide variety of vertebrate traits ranging from the formation of alveoli (Rubin et al., 1994), to glomerular filtration (Bosch et al., 1999), bone calcification (Simmonds and Kovacs, 2010), skin barrier formation (Philbrick, 1998) and brain regeneration/function (Gu et al., 2012).

As alluded to above, microgravity causes yeast, lung and bone cells alike to devolve into a seeming state of 'suspended animation'. Hameroff (1998) has suggested that anesthetics have the same net effect physicochemically. It is hypothesized that this is the biologic equivalent of what is referred to in QM as wave collapse due to dissociation of the process (consciousness) from its physical environment, in this case that of gravity (Schlosshauer, 2005), which is intimately linked with the fabric of space-time (Einstein, 1916).

The central and peripheral mechanisms integrated by PTHrP, for example, are the epitome of holistic physiology, providing insight to the nature of consciousness, acting to interconnect the cells of the body physiologically. Beyond that, because of the connection to physics as gravity, there is a continuum from the inanimate to the animate that was produced by the Big Bang, to which all of these properties are referenced by QM. As a result, the process of evolution can ultimately be expressed mathematically as a function of QM as it applies to ontogeny and phylogeny.

9. Discussion

9.1. Synchronic v diachronic

The Periodic Table acts to construct an algorithm for understanding the interrelationships between the elements based on atomic number. That, in turn is due to Pauli Exclusion Principle, which confers both determinism and probability on physics; like the Periodic Table of Physics, a cellular perspective on biologic evolution as the First Principles of Biology provides the mechanistic link to Physics, the former similarly indicating that biology exists between the determinism of negentropy and the probability of homeostasis.

The common thread between physics and biology is that both are predicated on self-organization and self-reference as their operating system. The origins of these properties are not known, though, for example, there is now empirical evidence that atoms of Yttrium will align themselves spontaneously (Zhang et al., 2017), indicating that there is a mechanism for self-organization.

Speculatively, there is a consensus that the Cosmos resulted from the explosion of the Singularity, known as the Big Bang (Singh, 2005). But Newton's Third Law of Motion would dictate that for every action there is an equal and opposite reaction. Based on parsimony, since the only organizational frame of reference in existence at that time was the Singularity, hypothetically biology was the consequent manifestation, acting like a pseudo-singularity. This concept is consistent with what we know of epigenetic inheritance, actively accumulating 'marks' that are assimilated by the germ cells of the adult, imparted to the offspring during reproduction. This scenario is one-hundred-and-eighty degrees out of sync with Darwinian evolution, which imbues the adults, not the egg and sperm, with agency for Natural Selection through mate selection. Thus, like the Red Queen in "Alice in Wonderland", the unicell is doing everything in its power to maintain the equipoise formed by the Singularity, delegating the offspring phenotype to interface with the environment in order to optimally collect data to carry back to the germ cells, zygote, embryo, and offspring of the next generation. And even beyond the offspring, the entire life cycle mediates the collection of marks since the endocrine system itself is under epigenetic control (Zhang and Ho, 2011). By seeing the process of evolution from the cellular perspective, many otherwise dogmatic aspects of biology can be understood mechanistically, including heterochrony (Torday, 2016c), homeostasis/homeorhesis (Torday and Rehan, 2012), pleiotropy (Torday, 2015), the life cycle (Torday, 2016a), the cell (Torday, 2016b), and phenotype (Torday and Miller, 2016c).

Like the advent of Heliocentrism, this novel perspective on evolution provides a wholly different concept of origins and causation in biology. It is reminiscent of Waddington, envisioning a horse and cart seen through a window, exhorting us to think of the horse as more than just what we can see before us because there is an arc of evolutionary history just below the surface (Waddington, 1957). By connecting the dots between physics and biology, there is a continuous path from the Singularity/Big Bang to the period at the end of this sentence.

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