Title: Quantum Mechanics Predicts Evolutionary Biology

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Running Head: Quantum Mechanics and Evolution

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 (QM) to evolutionary biology, application of QM to 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 confers 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 deterministic, whereas non-localization, and the Heisenberg Uncertainty Principle are probabilistic, providing the long-sought ontologic and causal continuum from physics to biology and evolution for the first time.

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 entail the direct application of the principles of QM to the overt physiologic properties of biology, rather than to their ontologic origins and epistemologic causal mechanisms (Torday and Rehan 2012). It is like trying to understand the internal combustion of an automobile by applying physics to the wheels or transmission. However, as will be shown, application of QM to the fundamentals of evolution reveals its principles and offers the authentic opportunity of understanding how and why physics constitutes the basics of biology (Torday and Miller 2016a).

Quantum Mechanics and the Origins and Causation in Biologic Evolution

There is a consensus that the Laws of Physics determine all of the Natural Sciences (Birks 1962), forcing the question as to how physics has determined the principles of biology. A number of physicists have attempted to answer this question (Prigogine and Stengers 1984; Polanyi 1968; Schrodinger 1944) but have failed, Prigogine, Stengers and Polanyi concluding that biology is too complicated. On the other hand, I have stated that life is actually simple (Torday 2016a). We complicate it (Barrow and Tipler 1988) from our narcissistic, self-serving perspective by reasoning after the fact (Bohm 1980). The portal by which physics enters biology is not through its present synchronic form, but in its diachronic, across space-time origins and mechanism of evolution (Torday and Miller 2016a). Although it can be argued that we cannot know the origins and causal mechanisms 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 1959). 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 of life based on the premise that evolution is pre-adaptive, or exaptive, or cooptional (Gould and Vrba 1982). **[Fig.1]** 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 spontaneously form micelles when immersed in water (Hamley 2007), exhibiting hysteresis as molecular memory, 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 for life (Torday and Miller 2017). Under these conditions, several principles of Quantum Mechanics arise- namely the Pauli Exclusion Principle, non-localization, and the Heisenberg Uncertainty Principle (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

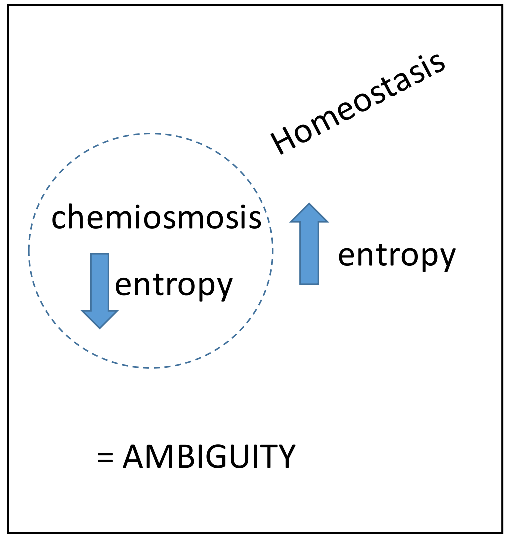

Fig.1. Origins of Life. Lipids immersed in water formed micelles that delimited the internal and external 'environments, allowing for negative entropy fueled by chemiosmosis within the cell, governed by homeostasis. The differential internal negative and external positive entropies generated the ambiguity of life.

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 when filling the electron's quantum energy state (Krane 1987). The last quantum number is time-based, offering a range of probabilistic electron energy levels, constituting 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 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 result of the mechanism of evolution, acting to identify genes in the organism's history that could be used in 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 driver for the subsequent evolution of the organism over time. It forms a means of interfacing with the physical environment that exists in an 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, Neils Bohr (Baggott 2011) explained the seemingly ambiguous 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, as described above. So perhaps it is because like physics, 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*.

Predictive Value of a Quantum Mechanical Approach to Evolution

Calcium Homeostatic Control by Lipids as the History of Vertebrates

It has previously been shown **[Fig. 2]** that the direction and magnitude of genetic change can be seen as alternating 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

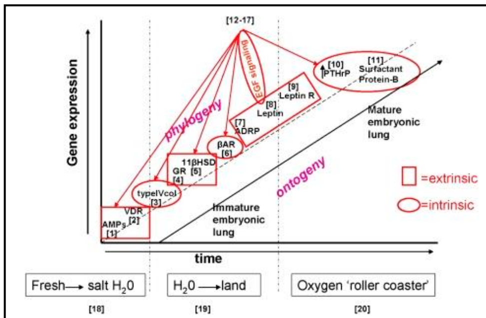

Fig. 2. Alternating extrinsic and intrinsic selection pressures for the genes of lung phylogeny and ontogeny. The effects of the extrinsic factors (salinity, land nutrients, and oxygen on the x-axis) on genes that determine the phylogeny and ontogeny of the mammalian lung alternate sequentially with 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.

carbon dioxide in the atmosphere (Berner 1990), causing acidification of the oceans, leaching calcium from the rock (Mitchell et al. 2010). Calcium is toxic in high levels biologically, so calcium channels 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, and calcium leak into the cytoplasm. In response, the cell responded by forming Peroxisomes, which utilize lipids to neutralize the otherwise deleterious effects of increased cytosolic intracellular calcium (De Duve 1969). The entraining of intracellular calcium was followed by its control through cell-cell interactions mediated by coordinated effects of soluble growth factors and their receptors, always referencing the First Principles of Physiolgy (Torday and Rehan 2012).

The Unicell-Multicell Approach Predicts the Evolution of Niche Construction

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 (Gabaldon and Pittis 2015). 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 caused physiologic stresses on life forms. By tracing the phenotypic changes in the gas exchanger under

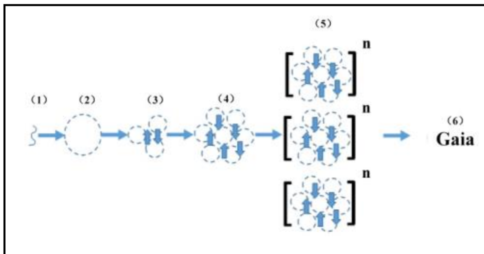

Fig. 3. Interaction between Niche Construction and Epigenetic Inheritance. (1) lipids in water spontaneously form micelles (2) delineating the internal niche construction of the protocell; (3) communication between cells promotes cell-cell communication; (4) metabolic cooperativity gives rise to multicellular 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.

such regimens, the evolution of the mammalian lung was traced from its unicellular origins forward (Torday and Rehan 2017).

The Forward-Direction of Evolution Predicts the Role of Quantum Mechanics

Similarly, QM can be applied to this process by considering its impacts on vertebrate evolution with regard to 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 spin of the second. The other two quanta fill the electron shell randomly. 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 and positive 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.

Is There a Homolog for Quantum Coherence?

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 it diachronic origins (Sherrington 1957), microtubules are elements of the cytoskeleton, which acts as the transducer of 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 to a seeming state of 'suspended animation'. Hameroff (1998) has suggested that anesthetics have the same effect physicochemically. I hypothesize 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 (Scholosshauer 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.

Discussion

Synchronic v Diachronic

The Periodic Table acts similarly 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 systems. The origins of this property are not known, though 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. This may be a manifestation of coherence, again pointing to QM as the fundament of all things physical, including biology.

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