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Quantum Weirdness and Living Systems: A Personal Perspective

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Abstract

Two related issues are discussed from the point of view of a molecular-cellular immunologist of 47 years standing. The author began training as a scientist at Adelaide University in the late 1960s. Initial interests were in Immunochemistry and in antibody-mediated mechanisms involving Secretory IgA of intestinal protection against infectious diseases (Cholera). Later, in post-doctoral studies this matured through Autoimmune mechanisms to molecular mechanisms of Somatic Hypermutation in antibody diversification and immunity, and more recently in Genomics, Evolution and Cancer. Part and parcel of this thinking led to the emergence of non-Darwinian (Lamarckian) evolutionary soma-to-germline mechanisms of evolutionary progress and adaptation. More recently, he has fully accepted the Hoyle-Wickramasinghe (H-W) Cosmic Biology Paradigm (1970s ->) because it is, in his opinion, a correct and precise overarching theory to explain and understand the origin of, and further evolution of, life on Earth and thus throughout the Cosmos. All other theories of Life on Earth need to play second fiddle to H-W theory and its subsidiary explanations. So this paper takes H-W thinking about life in the Universe into two further domains, both of which can indeed be studied here and now on Earth in a rigorous manner. Thus after 47 years publishing in conventional refereed journals and books, the author confronts the two big issues at the interface between Biology and Physics. He is convinced they will increasingly dominate thinking as the 21st century unfolds: a) Quantum Weirdness and Living Systems, b) Biological Transmutation (or "Cold Fusion" in Biology). Both these topics are related. Both evoke strong emotional and intellectual reactions. Both need to be confronted in a cool and rational way. Normally Physicists have purchased a mortgage on all types of rational discussions in this domain - with very few (if any) biologists daring to tread on this sacred physical ground. So I am now daring to tread into the assumed generality of Quantum Mechanics. I do this from the point of view of the biological experiences and historical perspective of the author just outlined. There will be no mathematics, just discussion and arguments in plain English prose. This essay arose when I finally addressed the question - "What do I have to lose in a reputational sense from confronting such issues"? My answer - absolutely *nothing*. At least nothing that is important to me at my age and stage in life.

Preamble to the problem*

My colleague Dr Kenneth Augustyn of the Center for the Physics of Living Organisms, (Department of Physics, Michigan Technological University, Michigan) has recently reminded me that over the past few 10-15 years " ...many biological functions have been found to depend on quantum effects that transcend classical physics" (Kenneth Augustyn Pers. Comm. email 26 May 2017). In particular, he refers me to Seth Lloyd (2014), and to Salari et al (2011). To this I would add the increasingly special biophysical properties of water in living systems (e.g. Davidson et al 2013) and maybe there are other proxy examples. The growing interest in building quantum computers has inevitably led to these wider developments. Here I will add to this discussion with my own personal perspective as a molecular cellular biologist interested in a number of areas of genomic diversification and adaptation, including the theory and data embracing Hoyle-Wickramasinghe Cosmic Biology (Steele et al 2017).

I clearly recall when I *first engaged* with this problem. To me the first comprehensive articulation since Schrodinger, that "living organisms may be quantum coherent" was outlined in a most remarkable and original book (first published in 1993) by the evolutionary geneticist and biologist Mai-Wan Ho - *The Rainbow and the Worm- The Physics of Organisms*. Her book built on the work of the German-born British solid-state physicist Herbert Frohlich. This data-based and data-rich book straddled Biology and Physics and went through multiple print runs, and editions, and is a science best seller – a rare achievement in itself given the fundamental nature of her critical arguments. In my view, as a connoisseur of scientific discovery, Mai-Wan Ho's book is amongst the most original half dozen books I have ever read. It should have been cited in many places in the 2014 popular science book by Jim Al-Khalili and Johnjoe McFadden (*Life on The Edge*) where they discussed the coming age of quantum biology. However it is unfortunate that it was not. Be that as it may Mai-Wan Ho was awarded the Ilya Prigogine Medal in 2014 for her life's work outlined in her book. Sadly, she is no longer with us.

The most striking, yet obvious fact, when you stand back from the problem and coolly survey the scientific terrain is this - the difference between "living" and "dead" molecular chemistry and processes. The difference is both common place yet profoundly striking. In a simple

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experiment Mai-Wan Ho compared the 'quantum electrodynamic' emissions of living and just killed *Drosophila* larvae. In the dead the coherent QED signals indicative of crystalline liquid chemistry (the "coloured rainbow" of the title) are completely ablated. To this naïve observer there is something *very special* about the 'electrical state' of living biochemistry of supramolecular structures within living cells, compared to the same biochemical components in freshly killed cells. There are clear signs other expert in the problem agree (Bernroider 2017).

Presumably these differences relate to the quantum state of their shared electrons involved in covalent bonds, and other non-covalent interactions such as hydrogen bonds e.g. base pairing between DNA and RNA polymers directing DNA synthesis (Replication), RNA synthesis (Transcription) and Protein synthesis (Translation). So living physical chemistry really is *very different* in its time and motion *organization* from the inanimate despite the physical chemistry *being the same* as the living. This is a striking fact which is not pointed out often enough.

Living systems are also real, naturally evolving, complex information systems. An astute biomedical colleague (Greg Nigh pers. comm. July 3 2017) has neatly summed up the key issues surrounding the Genetic Code: " Cells have operating within them at least 20 different, yet interdependent, languages. These are symbol systems which could not have possibly been generated by any kind of chemical (or quantum) laws that necessitated that, for example, TGC = cysteine. TGC could have represented a different amino acid. It didn't, and in fact as you probably know, the triplet coding system that is used for building amino acids is greater than 99% optimized! Of all possible ways to match up triplets with amino acids, the system that got chosen is optimized along 5 concurrent analyses (error minimization, functionally similar amino acids mapped to similar triplets, etc)."

Indeed, we can boldly state that biological systems at the molecular level are *highly no-random in the extreme*. They are information rich and information dense. They are unbelievably multi-factorial and supramolecular (many specific protein and nucleic acid polymers interacting and transacting). Their functions are both specific and pleiotropic, numerous and different biochemical transformations (catalysis, the breaking and reforming of

covalent bonds, and hydrogen bonds) happening at great speed in real-time all over the cell simultaneously and fueled by high energy chemical bonds (ATP) generated elsewhere in other membranous-enveloped compartments and vesicles within the cell. This is not a computer in the ordinary sense - this is a typical living cell. If anything it could be a micron scaled "Cray - Supercomputer" (but probably not a "quantum computer"? Pers comm. K Augustyn) .

The extraordinary coupled-harmony of the processes of the electron (e^-) transport chain allows Peter Mitchell's cross-membrane proton (H^+) pumping of the inner mitochondrial membrane, leading to the generation of the high energy phosphate bonds in ATP molecules. Then there is the capture and energy transduction of photons at chlorophyll interfaces in photosynthesis in plant chloroplasts and bacterial cells. The list goes on. There are so many different molecular processes of housekeeping maintenance and repair (e.g. DNA), happening *simultaneously* all around the cell.

A calm human mind standing back from the problem and contemplating it all is simply left with just one type of response - spellbound, the conscious mind literally boggles! There is no other way to describe our honest reaction here. We have become blasé and lost our sense of wonder if this fact is not sinking in.

The mathematician and philosopher David Berlinski has neatly summed it all up in his famous 2001 essay in *Commentary* magazine: *What Brings a World into Being*? His essay is required reading as a necessary corrective to our overweening human pride and arrogance.

Quantum Weirdness and Living Systems

My first question then is this: How universal is "Quantum Weirdness"? That is, How universal is Quantum Mechanics as we presently understand it? - The Heisenberg Uncertainty Principle, Quantum Entanglement, Wave-Particle Duality, "The Collapse of the Wave Function" at room temperature, and so on.

My key question is whether the known features of "Quantum Weirdness" established in inanimate, non-living systems have been actually tested in biophysical experiments on living systems?

I assert these experiments remain to be done.

So we re-phrase the issue: Are all the features of "Quantum Weirdness" and contemporary Quantum Theory applicable to living systems? Using Occam's Razor, an older scientific principle, now upgraded to "Popperian Refutation", I put the question:

How certain can we be that the principles and rules discovered by Rutherford-Bohr-Feynman are really applicable, in every respect, to living systems?

Indeed, in these early decades of the 21st Century it is now appropriate, I believe, that we question the fundamental foundations and assumptions that living systems can be described completely by contemporary theory in Physics.

I would go as far to say, following Karl Popper and David Hume, there is no reason for us to believe this assumption to be correct - however widely held it may be among contemporary scientists.

Why? Because, to reiterate, the proposition *has not* undergone a proper "Popperian" investigation aiming to refute the explanatory domain of current Quantum Mechanics.

So the key experiments have not been done.

Can we say with absolute certainty that if we could properly probe, or construct a Biophysics experiment, to investigate the current extant " Quantum Properties" of (say) a hydrogen bond between a water molecule and a hydrogen atom already engaged in a molecular (covalent) bond with (say) a sugar molecule, that the answer would be compatible with "Quantum Weirdness"? And what about the hydrogen and oxygen atoms involved in H-bond paring in A:T and G:C base pairs in the DNA double helix?

We must get real here, we simply have not done these critical Popperian experiments. Before we can make such assumptions we must do the test. We must do the experiment.

How do we do the experiment?

I believe that this experiment belongs to the new "magic technologies" (molecular probing using newfangled lasers?) of the future - not right now.

Prediction

I believe that the logical uncertainties (to the human mind) of current "Quantum Theory" (as expounded most eloquently by Richard Feynman viz.in his " *If you think you understand quantum mechanics, you don't understand quantum mechanics*") will evaporate when we apply the same rigorous biophysical probing to living systems. Indeed, I will make a bet - I bet that in the future "Quantum Weirdness" as we currently understand it in the terms Richard Feynman has so eloquently summed up, *will evaporate*.

In the future we will discover in living systems that cause-effect processes will "happen" at the "Quantum Level" in the same logical way they happen as they do in "macroscopic" Newtonian systems. As incredible as it may seem Albert Einstein and David Bohm will be proven correct - 'There are hidden variables' and 'quantum illogicality' will evaporate as we properly describe "living", as opposed to "dead", complex systems. So " God indeed does not play dice."

In living systems interactions and transactions between atoms and molecules will be shown to be predictably reliable, to use a very imperfect metaphor, just like the extant cause-effect chains in the biochemical pathways pinned in large posters on the corridor walls of a standard University Biochemistry teaching department.

So this is the first main challenge of 21st Century Physics.

Biological Transmutation

The second main challenge is "Biological Transmutation". This would otherwise be known as "Cold Fusion". The field has been reviewed by Biberian (2012, 2015). The claim is that the earlier experiments of Louis Kervan have now been confirmed in principle by Vysotskii and Kornilova (2015). I have found this work very difficult to follow because the mathematics are beyond the author. However, the paper by Solomon Goldfein of 1978 is clear and precise and provides a plausible molecular mechanism within the mitochondrion. It is on that basis I recommend Goldfein.

I have read enough of the literature recommended by Biberian to convince myself that there may be something in "Biological Transmutation". I am less sure of the reliability and reproducibility of "Physical Transmutation " as in the Fleishman - Pons type of experiment of 1989.

The key for me is the provision of a plausible mechanism. And that is why I think Solomon Goldfein was ahead of his time and on the right track with his extraordinarily important paper (below).

The plausible mechanism for me would meet criteria within the perspective of the Hoyle-Wickramasinghe Cosmic Biology Paradigm (reviewed in Steele et al 2017). For example, plant seeds travelling in deep space within a cometary protective matrix. On a soft landing on a planetary body with adequate water the seeds could both germinate and provide the necessary trace elements (and salts) it lacks in that particular landing location via an endogenous "biological transmutation" process during seed germination.

So this provides a plausible *raison d'etre*. The Goldfein conjecture provides a plausible molecular mechanism (even if it turns out to be incorrect).

But first we want to be absolutely sure that the reported examples of Biological Transmutation phenomena are real. It would also be useful that the reported examples of non-biological “Cold Fusion”-type phenomena (Fleishman-Pons) are also real. My tentative conclusion in reading the literature assembled by Biberian is that "Biological Transmutation" may well be reproducible and thus "real". The non-biological "Cold Fusion" type experiments may well indicate a real phenomenon, but the experiments have too many unknown variables and may not be strictly reproducible. Between these two extremes there could be a working mechanism ready for discovery - but I am not a physicist. My explanation and expectations come from molecular biology and biochemistry. That is why I find Solomon Goldfein's 1978 paper plausible.

The types of transmutations examined in the seed germination experiments consider:
Sodium to Magnesium (Superscript Atomic Weight; Subscript, Atomic Number)

$$^{23}Na_{11} + {}^{1}H_{1}^{+} \longrightarrow {}^{24}Mg_{12}$$

Potassium to Calcium

$^{39}K_{19}$ + $^{1}H_{1}^{+}$ ⟶ $^{40}Ca_{20}$

Manganese to Iron

$^{55}Mn_{25}$ + $^{1}H_{1}^{+}$ ⟶ $^{56}Fe_{26}$

A typical variation between seeds and sprouts in a Louis Kervran (1901–1983) type of seed germination experiment, as outlined by Biberian included the following type of summary:

	SiO_2	Ca	Mg	K
Seeds	111 mg	28 mg	27 mg	108 mg
Sprouts	123 mg	116 mg	27 mg	70 mg
	+10%	+314%	0%	–35%

I do not know, nor can I judge, how reliable these data are.

But what I can discern it is a disarmingly simple experiment to do using modern techniques in a standard modern Biophysics laboratory. A simple chemical analysis of Inputs *versus* Outputs in a closed germination system using chemically defined water (with all trace salt impurities quantified). The conduct of enough careful trials should either confirm or refute all such claims in independent Biophysics laboratories. We await such results.

Vladimir Vysotskii has claimed positive results in bacterial systems - but, as indicated, I find him very difficult to follow. This is complicated also by the fact that I am not a professional Physicist and do need to refresh myself with basic physical and quantum chemistry concepts. However, the whole concept of Biological Transmutation is so important to either refute or confirm it is worth putting the scientific effort in - by Biophysics laboratories to resolve whether such simple claimed phenomena are real. These are straight forward seed germination experiments and will establish whether such phenomena are true.

But the whole topic is really fascinating. I have read enough to feel there could be something of value. The key, as with all these things, is a plausible mechanism. It just has to be plausible when dealing with "out-of-left-field" phenomena like these.

The Solomon Goldfein article was extraordinary clear and years ahead of its time, in my considered view. I have always felt the Mitochondrion is far more mysterious, than even Peter Mitchell imagined - his "proton pump across the membrane" as electrons flow down the

electron transport chain, was, in its day in the 1950s -1960s, a revolutionary and imaginative proposal. However, when you think about it further you feel there are still scientific missing links. Photosynthesis is in the same mysterious category. Relativistic speeds such that the Mitochondrion is effectively an assembly of "microscopic particle accelerators" (micro-cyclotrons!) is an extraordinary important concept advanced by Solomon Goldfein.

This work is so important yet the scientific world in the second decade of the 21st Century may not yet be ready for it - that is why the first step must be rigorous experiments aiming at Popperian Refutation.

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