

The Life of Facts - Quantum Driven Biological Processes

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A Two Decades Dispute - The Importance of Tunnelling in Enzymes Functioning



The informative Philip Ball's By chance, or by design? published in Nature's New feature section [1] by two decades ago, addressed the controversies and implications of a contemporary scientific fetish to the fundamentals of several biologists research activities:

I. Quantum mechanics: The pivot of this story was the dispute between evidence that quantum tunnelling occurs in enzymes, playing an important role in their functioning, and the conclusions from other researchers showing that tunneling is doing nothing special. Also raised, at that time, was the question of whether enzymes have evolved to make the most of quantum tunnelling, which provoked a heated discussion. At the end of his New feature article, Philip Ball stated [2]: The debate shows little sign of being resolved quickly. And until it is, we must remain uncertain about the limits of nature's ingenuity (sic).

It is our opinion that currently, twenty years after the reporting of such dispute, instead of nature's ingenuity we are led to consider researchers ingenuity, as outlined below.

The Ubiquity of Tunnelling in Bioprocesses: To Serve and Protect

It seems that the protagonists of the above mentioned dispute have missed the point, and we would like to tentatively restore the nature and the fundamentals of the events, namely, that the tunnel effect (1) is a ubiquitous property of matter, associated with its particle-wave duality, and that (2) it plays an important role in biological processes closed related to LIFE. Some of the key bioeffects, where tunnelling is of paramount importance, are those related to life promotion and protection. Among them we underscore below two examples.

I. DNA repair mechanisms: Which are essential for the maintenance of genomic integrity. And that makes sense, merely because life is a final and sophisticate product elaborated by the quantum nature of inanimate matter [2]. For instance, signaling and recognition of DNA damage by repairing enzymes are driven by electric currents induced at and by the damaged region, and the intensities of these currents are crucial for the success of repair. These currents exist because of electron tunneling through AT-barriers (electron hopping from GC to GC) [3-6]. Thus, tunneling helps to protect the achievements obtained from evolution by protecting the genes regions of the genome.

II. DNA replication: where base-pairing is highly more efficient and faster because it is assisted by a polymerase, big and complex, responsible for the reduction of potential barriers accelerating, therefore, quantum tunneling [2].

Besides tunnelling, there is a plethora of other quantum effects in Biology [7-9]. Among them, I recommend to the reader quantum entanglement in photosynthesis [8], responsible for the enormous productivity of the photosynthetic process maintaining, thus, the life in our planet.

Final Remarks

It is obvious, therefore, that tunneling could represent an important advantage to life, and small changes in the many parameters governing it could result in substantial enhancement or hindrance of the whole process. Suitable alterations of some biochemical parameters promoted by the biological system itself, particularly those altering the height and/or width of

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the molecular electrostatic potential barriers, could enhance or inhibit the tunnelling rate. In this sense, life could have effect on tunnelling by dictating its rate. This is at variance with another statement quoted from Philip Ball's *By chance, or by design?* tunnelling is a fact of life, but life has no special effect on tunneling [1].

Then, if someone is puzzled by some questions, such as if enzymes do or do not use tunneling for their functioning, he may recognize that if he cannot understand something which follows from the wave-particle duality, it is that duality which he does not understand. He should perhaps address his concern at the source of problem and may not likely to resolve it by thinking about some remote consequence.

Actually, tunnelling, a quantum characteristic of the so-called "wave-particle duality", and the whole Quantum Mechanics itself, were created at the inauguration of the Universe. In the Cosmos time scale, life is a recent occurrence.

Quantum mechanics does not tell us what nature will provide but does tell us the behavior of anything we can define and specify, either as a particle or as a wave

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