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Biology-Physics the Missing Link?

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Abstract

Writing in 1943, renowned Austrian physicist Edwin Schrodinger asked "What is Life?" thereby invigorating the debate which preoccupied biologists at the time. He proposed an answer to this question rooted in considerations borrowed from Thermodynamics and Statistical Mechanics. To reveal the missing link in Biology-Physics, the present Note investigates an alternate answer in which dynamical action, rather than thermodynamics and energy, plays the fundamental role. It reviews in particular the process of biological cell replication which may be considered to define "Life" and might be the macroscopic manifestation of an underlying quantum physical process in which xons, conveyors of dynamical action, are the determining agents.

Keywords

Schrödinger, Dynamical Action, Planck, Quantum Physics, Biological Cells, Molecules, Electrons, Strings, Branes, Xons

1. Introduction

Biologists study organisms which possess a mysterious attribute—we call it "life". Physicists, by contrast, investigate systems which *seemingly* lack this attribute. A gap thus appears to separate in depth the two disciplines—Biology and Physics.

Can this gap be bridged?

This is a worthy question to consider.

In the 1920s, pioneer geneticist (and future Nobel laureate) Hermann J. Muller put forward the conception of the gene as constituting the basis of life, as well as of evolution, by virtue of its possessing the property of *reproducing its own changes*. He saw in this phenomenon the seminal problem of living matter.

In February 1943, renowned Nobel physics laureate Erwin Schrödinger, then a WW II political refugee at the Dublin Institute for Advanced Studies, Trinity College, Dublin, followed in Muller's footsteps in a series of lectures he later published as a book under the title "What is Life?" [1].

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Schrödinger's primary concern in this undertaking was to try to comprehend, *as a physicist*, how living organisms manage to extract "order out of disorder" in apparent violation of the Second Law of Thermodynamics which asserts that entropy (disorder) is continuously on the increase in the universe. He asked: "How can the events in space and time which take place within the spatial boundary of a living organism be accounted for by physics and chemistry"—a question with obvious genetic connotations.

We shall adopt in the present Note a drastically different starting point. It derives from the following series of related questions and answers.

2. A Series of Related Questions (Q) and Answers (A)

Q. What structural ingredient do all biological living organisms have in common?
A. The biological living *cell*.
Q. What structural ingredients do all biological living cells have in common?
A. *Molecules*.
Q. What structuring ingredients do all molecules present in biological living cells have in common?
A. *Electrons* (explanation below).
Q. What structuring ingredient do all electrons acting in biological living cells have in common?
A. The xon.
Q. The *Xon*?
A. See [2] [3].
Q. What structuring ingredient do all xons acting in molecules present in biological living cells have in common?
A. *Action*.
Q. *ACTION*…?
A. Originally *Actio* (Leibniz).
Q. *ACTIO*…?
A. Let us review in detail how the concept referred to under the designation *Actio* came to be defined and what it signifies today.

3. *Actio* for Biologists and/or Physicists Who Might Have Never Heard of It

I pick up a stone and throw it away. High speed cameras record the trajectory in space and the trajectory in time the stone follows to go from point A to point B.

Q. What caused the stone to select (to follow) these particular trajectories in space and in time to go from A to B rather than some others?

A. French philosopher—as well as mathematician, astronomer and precursor biologist!—Pierre Louis Moreau de Maupertuis identified this cause in 1744. He gave it the name "Principle of Least Action" [4]. According to this Principle, to go from A to B the stone follows—spontaneously!—the trajectories in space and in time for which the spending in "action" to go from A to B is *the least possible*.

Q. *Action*...?

A. Forged from the Latin word *Actio*, the modern word Action refers to a concept German diplomat, philosopher—and mathematician!—Gottfried Wilhem Leibniz placed at the heart of his newly invented science of Dynamics (*Dynamica* for him) in 1689 [5].

4. Leibniz's *Actio* Receives a Boost

Leibniz's *Actio* concept acquired tremendous significance in December of 1900 when Berlin physicist—and musician!—Max Planck established his famous *Black Body Radiation* formula which suggests, among other things, that action always occurs in Nature in the form of *elements* all containing the same quantity (*quantum* for Planck) of said action. To designate the action element he had thus (accidently!) uncovered, Max Planck coined the appellation *Elementary Quantum of Action*—Elementares Wirkungs quantum for him—and elected the symbol *h* to represent it in formulas [6].

5. On the (Mis)Use of Words

Max Planck's use of the Germanized Latin word *quantum* in his labeling—he meant it to signify nothing more than the ordinary word "quantity"—soon led physicists astray. Ignoring the all-important qualifier "elementary"

Planck had associated to it in his formulations, they weakened the significance of his symbol *h*, calling it unabashedly "Planck's *constant*"; began to speak indiscriminately of *quanta*; and, aggravating insidiously the situation—with the notable exception of Nobel laureate Richard Feynman in his celebrated *Lectures on Physics* [7]—surreptitiously banished the word "action" from their vocabulary—it does not appear in the index of Lee Smolin's famed *The Trouble with Physics* for instance [8]—replacing it inconspicuously by the word "energy", even though Quantum Physics is, by nature, the science of dynamical action—not the science of energy!

6. An Illustrative Example

In two preceding Notes [2] [3], we explored the idea that the Planck's "constant" *h* is much more than a "constant": it fundamentally measures the (elementary) quantity—the "quantum"—of action carried by a hitherto unrecognised particle, the *xon*, and *w*e urged that it be treated accordingly.

Let us see this idea at work in a simple situation.

Consider the hydrogen atom, H.

Quantum chemists tell us that it is made up of a proton, dotted with a positive electric charge, e^+, which keeps in orbit around it an electron, itself dotted with a negative electric charge, e^-.

Q. Why doesn't the electron fall on the proton?

A. Classically, it should.

But it does not.

With his 1925-1926 invention of the equation which bears his name—the Schrödinger Equation—Erwin Schrödinger was one of the main architects of what became known as Wave Mechanics, a theoretical scheme which provides an answer to the question raised above based on (mathematical) considerations concerning *energy*—not action: the atom is said to be at all times in one of a series of allowed *states* each belonging to a specific *energy level*. Even while in its lowest energy level—its so-called *ground state*—the energy the atom contains keeps the electron permanently apart from the proton [7].

The scheme Schrödinger perfected on this basis works well (mathematically), but it creates the unwarranted illusion that energy is quantized—*i.e.* that it is made up of *elements* all containing the same *quantum* of energy—which of course is not the case; and it leaves unanswered this intriguing question: what is the underlying *mechanism* which keeps the thing going? In brief, how does the thing actually *works*?

7. The Electron, This Mysterious Entity…

We think we *know*—we think we *understand*—what an electron *is*, that elementary particle which carries the electric currents so indispensable in our everyday life.

From the viewpoint of pure physics, it is said to be dotted with three major attributes: it carries a rest mass *m*, an electric charge *e*, and a spin *s*.

As we discussed in our preceding Note [3], the electron spin has the dimensions of… dynamical action. When this is recognized, the electron becomes tributary of the xon! with considerable consequences.

Let us examine some of them.

8. How Xons Keep Molecules "Alive" in Biological Living Cells

As we pointed out in §2 of the present Note, the structural ingredients all biological living cells have in common are molecules. Consider the simplest of all molecules, H_2.

Made of two hydrogen atoms, it contains two protons which, left on their own, would repel each other out to infinity. But in H_2 they are not left on their own: they are accompanied by two electrons, and therefore by xons: *they* keep the protons "bound" together through a "covalent bond" at a distance apart of the order of 0.074 nm on the average. This stunning fact is usually presented in standard quantum physics (or chemistry) textbooks in terms of "energy" considerations similar to those we encountered during our (brief) study of the hydrogen atom: they say that the system's total energy is lower when the two protons are kept together at a distance of the order of 0.074 nm apart on the average, a statement supported by mathematical justifications of a nature apt to discourage non-experts. [A typical explanation might read something like this: "The symmetric wave-function for H_2 gives a high electron density between the protons, leading to a net attractive force between the atoms (a bond)"].

What interests us in this situation is something altogether different. Each of the two electrons in H_2 has a spin which contributes one action element—one xon—to the molecule. The two protons also have a spin which contribute two additional xons to the molecule. In fine, besides containing two protons and two electrons, the H_2 molecule contains four xons which engender manifest structural effects.

9. If It Walks Like a Duck, Quacks Like a Duck, Flies Like a Duck… It Is a Xon!

According to our theoretical scheme, the four xons present in the H_2 hydrogen molecule produce these all important effects:

1) They keep the molecular electrons busy, thereby preventing them from falling on the molecular atomic nuclei—protons in this case.

2) They also keep the molecular nuclei busy—the protons in the case of H_2—causing them to oscillate—to vibrate—around their average positions in the molecule.

3) They force the molecule as a whole to rotate permanently.

In fine, the molecule is compelled by the xons acting within its perimeter into a permanent state of internal agitation characterized by two outstanding considerations:

1) Unless the molecule is (chemically) broken apart or otherwise perturbed, its internal state of agitation will persist unabashed... till the end of time.

2) And, most importantly, this internal agitation requires *no expenditure of energy*.

In brief, xons—*i.e.* dynamical action, not "energy"—keep the molecule together, a fundamental requirement if this molecule is to play a role in the biological functioning of a living cell (incidentally a fact that Erwin Schrödinger well recognized in his *What is Life*? essay).

10. Replication as the Fundamental Mechanism of Life

Let us return to the seminal question Edwin Schrödinger raised in 1943 (and which has been (re)considered by many others ever since): *What is Life*?

As we briefly reviewed in this Note's Introduction, Schrödinger proposed an answer to this question founded in viewpoints borrowed from Thermodynamics and Statistical Mechanics, a legitimate starting point in the context of a time when biologists attempted frantically to identify the wondrous nature of the "heredity molecule" (then not yet known to be DNA) as one of them (Muller) called it.

We shall adopt here a different line of thought.

Consider the following experiment which biologists must have performed in their laboratories myriads of time.

Place a single biological cell—such as a bacterial cell—in an aqueous solution containing appropriate nutrients. After a short period of time (the length of which depends on the experimental conditions), the original cell has disappeared having given way to two "daughter cells" identical in all respects to the original "mother cell", a process biologists call "replication".

As performed by bacteria in particular, the cell replication process bewilders contemporary biologists, notably since they have identified the presence in bacteria of what they call "molecular motors".

What "fuel" makes these motors operate?

Biologists turn to physicists quite naturally for advice. They are told… in a whisper: *Energy*.

Stanford University wonder biologist Julie A. Thériot thus recently made this remark: "Obviously bacteria do have some kinds of molecular motors…" to which she added—advice from physicists: "… if we define molecular motors very generally as just being engines that convert chemical *energy* into mechanical *energy* [our emphasis]…" concluding: "which I think is a fair definition [9]."

Is it?

11. The Rule of Life

In 1943, Erwin Schrodinger saw the Rule of Life as Order-out-of-Disorder (genetics). We propose to see it here today as The-Many-out-of-The One (duplication).

This raises an intriguing possibility.

Let us examine it briefly.

In our preceding Note [2] we describe a System of the World—and we laid the foundations for a New Quantum Physics (NQP) in the process—in which xons, carrying quantized action elements, act as "active principles" capable of collecting "nutrients"—*i-points* in our terminology—from the passive, unstructured substrate which "surrounds" them. In the process, xons generate physical structures—space, time (duration), energy… *strings*, *branes*, *spins*… in brief, all the elements of the observable (or not so observable, *e.g.* dark matter and/or dark energy) universe.

Very well, but then how can one hope to fit such a scheme within the framework of existing Quantum Physics?

Indeed one might be tempted to see in the relation

$$Ed = h$$

which establishes a connection between energy in general (E), time duration (d) and the Planck constant h (the *xon*) an indication that any reasoning tending to substitute action for energy in its convolutions would have to be by nature necessarily *circular*.

Not so—for a simple, yet telling reason.

Space, time, *energy*... are *continuous* (analog) variables. Dynamical action—the xon—is by contrast an entity—the *only* entity—known to physicists today to be *quantized*—made up of elements—in the proper sense of the word.

Energy cannot be authentically substituted for action.

If this be, then one might want to go one step further.

12. After the Big Bang... Xonic *Little Bangs*?

We propose to consider the possibility that the observed process of biological cell replication which we have used in this Note to define "Life" might be the macroscopic manifestation of an underlying quantum physical process in which xons, conveyors of dynamical action, are the determining agents, creating the universe as we "see" it in a continuous series of... Little Bangs (hence dark matter/energy). This would establish a new, unexpected structural link—somewhat uncanny but surely worthy of further investigation—connecting Biology and Physics.

The *missing link*?

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