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Can a Molecule Be "Intelligent"? Unexpected Connections between Physics and Biology

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Abstract

It is important to look at the behaviour of a living system from the point of view of the biophysical paradigm. In fact, the chemical reactions, which allow us to understand how metabolic processes take place, are short-range and they are activated at a distance of one atomic or molecular diameter. 100,000 reactions/sec. take place in a cell, perfectly balanced in space and time, *i.e.* these happen at the right time and in the right place. So, it is chemically inexplicable how this can be possible, because it is absolutely necessary that molecules recognize each other at distances greater than a molecular diameter. The biophysical paradigm, through coherent resonance mechanisms, tries to explain how molecules can recognize each other "from afar". It is a matter of beginning to understand that, probably, the same atoms and molecules are endowed with a kind of "intrinsic intelligence" that guides them in their interactions, and the key to understanding can only be of physical type. We can also hypothesize that a cellular information mechanism based on endogenous electromagnetic fields exists. In this way, DNA could play a role of in-out antenna, due to its double helix shape (resonant LC circuit). This paper speaks about these unexpected, but not too many, connections between Physics and Biology.

Keywords

Resonance, Information, Biophoton, DNA Antenna

1. Introduction

The purpose of science is to come to a plausible, objective description of reality and the laws that control the observed phenomena (possibly with "predictive character"), starting from the yet unknown. Dealing with science means asking nature questions and trying to understand the answers, not believing in having the answers already to questions that have not yet been raised. It means having doubts, accepting that one's own ideas might be wrong or imprecise, and accepting that what we believe we know today might be questioned tomorrow. As Nobel Prize winner Francis Crick said: "*The real ability of science lies in the ideas and new hypotheses, regardless of whether they turn out to be right or wrong.*"

Medical Science and Biology have systematically and with almost absolute confidence been based on the biochemical paradigm in which it is, indeed, Chemistry that commands the reactions and metabolic processes occurring in living systems, and in the human one in particular. Although it undoubtedly allowed to obtain very important and decisive therapeutic successes for people's health, it is this confidence that leaves room for very critical questions related to understanding how the biological system (and its constituent parts) procedes and how it has the ability to self-regulate and self-organize, as well as to cooperate at an intracellular and intercellular level by adapting to an endogenous and exogenous exchange of information. These types of chemical reactions are short-range, as we know since the model of Heitler and London in 1927 (valence bond (VB) theory) on the formation of a hydrogen molecule starting from two elementary atoms [1] [2], *i.e.* they are activated at a distance between atoms or molecules that is equal to an atomic or molecular diameter. Yet, by focusing only on this point of view it turns out to be chemically inexplicable how in a living system molecules that are far more apart than a molecular diameter "look for each other" and "find each other" with absolute precision in the right moment and the right place, even though they have other molecules around them with which they could interact.

While it is true that in a chemical reactor, in other words, a container designed to make chemical reactions happen, a molecule reacts to the closest molecule with which it can bond, living systems are, indeed, not chemical reactors.

We therefore have to take certain aspects into account that have thus far been underestimated but could shed new light on the mechanisms that regulate living systems, and that fully include the biophysical paradigm that regulates medium and long-range exchange of information.

This way, we can follow another point of view which favors the search for the "logic" that controls the observed phenomena. We know very well, for instance, that the letters of the alphabet do not have any significance when considered individually and that knowing a single letter does certainly not mean knowing how to speak. The information, their meaning, lies in the relation with other letters and in the way they are linked together thanks to grammatical rules and syntax. Using this analogy with living systems, this means that in addition to the knowledge of the molecules involved and the physical-chemical forces that keep them together, it is necessary to understand the way in which these molecules interact on a short distance (short-range) as well as the interactions and ways of communication on long distances (long-range). In the case of living systems, we then understand it is not just a simple exercise of acquiring the rules of grammar in order to construct words and then sentences, or the rules of chemistry for molecules and then connections between molecules, but the research of their *relations* becomes the very soul of science. As written by the great Henri Poincaré: "the value of science is not in the things themselves […] but in the relations between them; without these relations, there is no knowable reality" [3]. And further: "we cannot consider an object if not in relation to the possibility of its connection to other things" [4].

Physics tries to come out of the schematization of planned processes according to linear sequences, precisely in order to elaborate an interpretation of the phenomena according to an overall view of the processes and events in question. Life itself can be seen as a structure of information which the whole is more important than the sum of the single parts.

2. The "Lock and Key" Model: Critical Issues

In immunology and biochemistry, one of the still strongly rooted cornerstones in the formation of students and in applied research is based on the so-called "Ehrlich dogma", modified by Clark [5] in which all phenomena of molecular recognition, in particular the transmission of information from a properly biochemical point of view, follow a strictly geometric mode of operation known as the "key &lock" scheme, expressing the fact that the interaction between two molecules follows the comparison of a key that is perfectly compatible with one (and only that exact) lock.

The possibility, therefore, that two molecules can interact with or "ignore" each other is associated with "elements of information" seen as simple geometric-structural abilities in a globally static system, whether correlated or not to the presence of certain groups of atoms, that can allow these interactions to express themselves in the form of donor, acceptor or ligand, receptor bonds through hydrogen bridges, disulfide bridges, Van der Waals forces, polarity. It would be these abilities in a given molecule to determine its own potentiality to interact with another molecule, like compatibility or incompatibility in computer programmes. Following this logic, the activation of biological functions is therefore a "mediation" between the chemical exchange of information of the molecule-receptor type and the spatial characteristics of the two substances. It is believed that the cell can operate with a specific selection of a greatly varied number of chemical signals, thanks to a likewise great specificity of its own receptors.

This fact is reported not only in ordinary biochemical reactions, but also in the way medication intervenes in correcting "functional defects".

Molecular biology, considered the conceptual basis for medical science, tends to concentrate all its attention to the interaction between molecules following a sequential process. The pharmacological action is aimed at favoring or preventing chemical communication by acting selectively on the emitters, the messengers or the receptors, by acting on the adaptability of the structures (*i.e.* the "key" that enters the right "lock"). It is, for that matter, not sufficient to enumerate these steps if we do not also specify the modality of chemical selectivity, in other words an *identification map* must be introduced through which molecules can correctly interact (so that molecule A can "find" molecule B).

However, because of the complexity of biological systems and particularly the enormous quantity of molecules concerned, we almost never succeed at defining which are the "sick" molecules.

This rather complex action becomes even more complicated if we consider that not only the adaptability of the structure, but also the number of contacts between interacting molecules (speed of formation and dissociation) is important [6]. This leads us to a "new" variable that seems to be completely overlooked in Ehrlich's dogma, which is time. The difficulties now broaden into space-time dynamics as it is not only important that molecule A "finds" molecule B, but also that is does so rapidly. This poses a divergence from the classic scheme of molecular biology which, dealing only with "close encounters" of molecules, is not capable of finding an answer to.

According to Rowlands, in the late '80s, it is inconceivable that molecules wander randomly in the cell until they (casually) manage to meet each other at the right time and the right place for a useful reaction [7]. Furthermore, Bistolfi confirmed around the same time [8] that biophysical research was moving increasingly towards an approach that took into account both the collective and cooperative properties of biological systems, as well as the ordered behaviour of dissipative structures, according to the work of Nobel Prize winner Prigogine. This approach has been confirmed in the work of various researchers and work groups [8] [9] [10] [11] [12].

3. Biophysics and Resonance Mechanisms

It is important to remember that when there is no correlation between molecules, the energy that is produced by the system will thermally disperse in the form of molecular kinetic energy. Whilst when molecules are associated, their movement is determined and stabilized by precisely those connections. We notice the same thing while observing a school of fish or a flock of birds: their apparently abrupt movements or sudden displacements are not commanded by one "leader of the pack", but through the *tuning of collective characteristics* of the elements in the system. This means coordination constraints are introduced, reducing on the one hand the possibility of performing all possible movements (collisions between elements of the system for example are excluded), allowing on the other hand the formation of collective coordination criteria so that the system can have a proper *identification map,* and the first step is the one of phenomena of resonance [13].

Resonance is the condition that occurs when a forced oscillating system is subject to periodic stress with a frequency that is equal to that of the system itself.

In Physics and Biophysics we continuously observe oscillating and periodic processes (processes that follow a rythmn: circadian, monthly, etc…) and we always strive to describe them in the simplest way possible, like sinusoidal waves or their composition. A periodic oscillating motion can be assimilated into the movement of the pendulum, which is then nothing more than a "variation" of the uniform circular motion.

In this case, we know from classical physics that a body that moves in a uniform circular motion is subject to continuous variations in speed over time as it gradually completes the circumference span during its movement (speed is a vector, described by the number that measures its value, direction and way). A variation of speed in time is nothing more than an acceleration, so a body that moves in uniform circular motion is an accelerated system, and therefore moves in uniformly accelerated motion.

We know that atoms and molecules (more or less "large") in a living system are not electrically neutral but present an unbalanced electric charge (such as positively or negatively charged ions and protein binding sites) to allow the formation of chemical bonds. From classical physics we know that an electric charge in uniformly accelerated motion is home to electromagnetic fields and quantum physics helps us to understand that these electromagnetic fields manifest themselves through the presence of photons (also called "quanta of electromagnetic radiation"). In living systems photons are called biophotons.

We begin to sense that biophotonic communication between one cell and another and between themselves and their environment forms the foundation of resonance mechanisms, where the endogenous electromagnetic field is the activator of such mechanisms [8] [11] [14]-[20].

Resonance is at the basis of cellular communication, hence the introduction of the biophysical paradigm which allows us to give a clear interpretation to molecular recognition that is extremely selective and harmonically synchronized in a living system, something that will not occur in a biochemical reactor.

As a result, also the so-called "lock and key" model finds an explanation that goes well beyond the "randomness" of ligand–receptor bonds, because of the interlocking of forms without any prior recognition that prepare the bond itself.

It is exactly on this initial base that a molecule becomes intelligent, because by resonating with physiological elements it interacts with, it is capable of identifying where to go and of recognising where it needs to act in order to either contrast an ongoing process or support a useful physiological action.

4. The "Lock and Key" Model: Overcoming Critical Issues

We know that proteins do not have a static structure but are dynamic, and thanks to their capability of taking on different, coherently linked forms, they can modify their functional activity. This characteristic, representing a regulatory mechanism in biological processes, is called allosterism and the proteins are called allosteric [21]-[27].

This mechanism allows proteins to ensure that their internal hydrogen bridging bonds, the disulfide bridging (SH) bonds and the Van der Waals forces can assume alternative but energetically similar positions, which is why new spatial relationships between the "folds" of the secondary and tertiary structure of the proteins can be formed, and consequently a modification of their form at the external surface level, thus allowing a different modality of interaction with other molecules.

Keeping in mind that the lateral chains of a single protein have superficial binding sites allowing weak bonds with ligands (in order to be reversible), these only occur if the ligand perfectly matches the receptor. Therefore, the modelization of protein, ligand binding describes a dynamic process of morphological adaptation of the binding site of the "receptor" protein to the "ligand" molecule [8] [28]; it is not a purely mechanical or geometric mechanism, but instead this is all mediated by what we previously defined as "identification maps and codes". To put it simply, proteins have binding sites (receptors) that can be structurally modified, form-wise, thanks to modifications of the lateral chain structure of the protein itself which are linked to signals coming from the molecule (the ligand) with which the protein interacts, thus to activated mechanisms of resonance.

5. Electromagnetic Fields and DNA Antenna

"How come we are not able to do what the lowest microbes can effortlessly accomplish?". In a recent publication, Al-Khalili and McFadden asked themselves why matter behaves so differently when it has to build an animated creature compared to when it manifests itself in an inanimate subject like a stone [29]. These and related questions make us realize that the development of an organism is not just the simple sum of its parts, but infinitely much more. Although the human-machine model is extremely useful in certain situations, it has become clear that we have to go beyond. Being anchored exclusively to concepts of classical physics and chemistry, it fails to explain the complexity in the behaviour of a living system.

The idea that DNA would "simply" be some kind of protein-making machine, as well as a "rememberer" of genetic information, is a cognitive limitation. We know that only a small percentage (from 2% to 10%) of its structure codifies proteins, in a pleiotropic way. Until recently, the remaining non-coding part of DNA (between 90% and 98%) was considered useless as it seemed "not to do much", leading to the term junk DNA. However, according to many researchers it is the non-coding part that controls the cellular complexity and regulates the behaviour of the coding part as it communicates through a grammatically and syntactically very precise and correct language which genes need to turn on or off for the synthesis of specific proteins [30].

A couple of new questions arise:

- How is it possible that DNA communicates with cytoplasm if it is seen as "just" a protein-producing machine?
- On the same premise, how can the nuclear DNA communicate with the mitochondrial DNA?

Let us briefly introduce a possible interpretation (working hypothesis).

Physically speaking, the spiral shape of DNA (double helix) represents:

- A solenoid, a coil of conducting wire wound in a spiral on a cylindrical-shaped support that generates a magnetic field when crossed by an electric current, consisting of a spiral winding of the external DNA skeleton;
- A series of capacitors, *i.e.* devices with parallel faces that store energy in an electrostatic field, consisting of the parallel faces of the spiral windings of the external structure.

This means that the DNA could be seen as a device that electrical engineers call an LC circuit, where L stands for the inductance of the equivalent solenoid and C for the capacity of the equivalent capacitor, which, at certain frequencies, is subject to the phenomenon of resonance.

DNA can store and release electromagnetic energy, thus information, in the form of biophotons.

This leads to think that the double helix structure of DNA allows this super-molecule to behave like a proper electromagnetic input/output antenna, capable of "reading" and "retransmitting" information signals of the electromagnetic type which come from various districts of the cytoplasm [8] [31] [32] [33].

It is exactly this electromagnetic information that forms the subject of communication between antenna DNA and cytoplasm. In this way, DNA can be informed about "how things are going" and whether it is necessary to proceed to replace or produce proteins in certain areas of the cell.

Moreover, the absorption spectra of DNA in the so-called "far infrared" region (more than 10 - 15 μm) indicate low-frequency molecular movements linked to the flexibility and deformation capacity of the double helix structure, which can then be bound up in the approximately 5 μm of the cell nucleus. This also allows the antenna to generate bio-phonons, or low-frequency fluctuating elastic waves [34].

The double helix structure as a transceiver antenna, combined with the deformability and flexibility of the structure [35], makes the DNA capable of encompassing an enormous range of frequencies and controlling the complexity of the cell in an extremely precise way. This lets the living system as a whole, as well as the component molecules, act like an intelligent structure capable of making decisions for its own (self-organization and self-regulation) based on exogenous and endogenous information flows.

On the other hand, this is a controversial issue, due to the experimental difficulty of making measurements on isolable DNA. In fact, in a paper of four years ago [36] based on an extensive investigation with both prokaryotic and eukaryotic purified DNA sample in concentrated or diluted form, to put in evidence electromagnetic properties inherent to it, the authors concluded that either there were no intrinsic EM activity in the DNA materials or any such activity was so weak respect on measurements limits of instruments used in these experiments.

So this model remain a suggestive working hypothesis because it is coherent with the accepted paradigm relating to the biophysics of living systems, but it is necessary to develop controlled experiments to correlate quantum coherent resonance with modalities of possible electromagnetic interactions between DNA and molecules. The main issue is that the claim to isolate a molecule from its biological context risks showing a fictitious reality, that does not correspond to the real behaviour of "that" molecule within the living system. So we must be very clear about what we consider acceptable ad inalienable and what is "expendable", in making an element of biophysical investigation isolable, such as a protein, a nucleic acid, water itself (which in this paper is not considered but will be subject to an in-depth review in a new paper).

6. Conclusions

I hope that the scientific community doesn't reject this interpretation "tout court", because it can be an opportunity for a better understanding of living systems, looking at the wonderful complexity of life from a different perspective.

In my opinion living systems, as well as single cells, can be described as autopoietic biological reactors in which each cell, in phase coherence with the others, is able to make conscious choices, thus expressing an adaptive intelligence. In fact, a living system can respond autonomously to external stimuli, reorganizing and adapting itself.

We tend to exclude weak signals, which are often difficult to detect compared to what we call background noise, but I think that precisely these weak signals can allow a coherent reorganization at the metabolic and functional cellular level.

These considerations, all based on our current level of knowledge, make us look at the wonderful complexity and incredible mystery that forms life with humility and respect.

"*As science gradually develops, it becomes more and more complicated to have an overall vision; so we divide it up into different pieces and are satisfied with one part; in one word, we specialize.*

Continuing like this would constitute a serious obstacle towards scientific progress. As said before: it is the unexpected connections between various scientific domains that make such progress possible." (J.-H. Poincaré)

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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