The Impact of a Pervasive Electrodynamical Background on Biological Interactions

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Daniele Funaro

Dipartimento di Scienze Chimiche e Geologiche
Università di Modena e Reggio Emilia
Via Campi 103, 41125 Modena (Italy)
daniele.funaro@unimore.it

Abstract

It is assumed that the background electromagnetic radiation is not just a noise, but a structured dynamical environment which is modified by the presence of matter, and, at the same time, promotes aggregations of elements at various scales of complexity. The process starts at atomic and molecular level, and extends its domain to evolved assemblies, up to the level of living beings. The first consequence of this interpretation is the fundamental observation that the whole is not strictly the sum of its parts, but a new arrangement, where electromagnetic waves resonate at frequencies different from those of the components, emitting photons in new energy ranges. The second crucial argument, is the possibility of establishing alternative means of biological communications either by direct way (biophotons), or through a suitable excitation of the electromagnetic habitat. A corollary of this analysis is that DNA can be interpreted as an active transmitting entity, rather that a mere list of crude instructions.

Keywords: electromagnetism, biophoton, DNA.

1 An immense electromagnetic environment

Before discussing more practical arguments, we dedicate this preliminary section to a brief presentation of the ideas developed in [1] and [2], where a model for the description of the structure of matter has been introduced and analyzed at growing levels of complexity. In particular, section 3.7 in [2] offers an attempt towards the comprehension of some basic biological phenomena. Here we would like to extend that short part by adding further results and considerations. The goal is not to provide answers to specific questions (also because, honestly, the author of the present paper is rather unprepared on these subjects), but to

indicate a path that could be possibly followed in order to arrive at a clearer understanding.

The first issue we would like to discuss is a description of the environment we live in. We start with the concept of vacuum, which is not actually coincident with the idea of void space. It is an electromagnetic background encircling everything. There is the tendency not to pay attention to its constitution, considering it as an unavoidable zero-average fluctuation. Notwithstanding, groups of researchers have proposed several constructive models of the vacuum ([3], [4], [5], to mention some of the numerous publications). According to [6]: *Even when all matter and heat radiation have been removed from a region of space, the vacuum of classical physics remains filled with a distinctive pattern of electromagnetic fields*. The interpretation of *Aether as a medium for conveying physical action across space* [7], was in vogue more than a century ago. The idea of Aether was abandoned, but the successive "upgrades" proposed by quantum theories were not able to ameliorate the knowledge. Officially, vacuum remains a blurred picture still waiting for a more rational formalization.

In this paper, we base our analysis on the assumption that the electromagnetic background is extremely organized and represents the backbone of matter. Encapsulated structures (that we will generically call: *shells*) surround nuclei, atoms, molecules, providing them with distinctive fingerprints. Once broken, a shell releases electromagnetic energy in the form of "photons", appearing to us with an immense variety of energy levels (see the explicative Fig. 5). Hence, vacuum is not "flat", it is not even a "noise", but assumes variegated forms depending on the objects that are immersed in it. The work in [2] was actually aimed at a quantitative validation of this aspect. For the sake of simplicity, we do not report here any technical detail, while we adapt the consequences of this vision to the subjects of this exposition.

Our primary observation is that nature manifests itself through a world of mechanical or electromagnetic phenomena displaying oscillations that range from the high frequencies of the subatomic environment to the low ones of the astronomical immensity. Photons are quantized electrodynamical emissions, formally associated to frequencies, although they are actually more resembling infinitesimal energy peeks. As it will be better specified in section 4, it is possible to recover a classical notion of frequency by assuming that, before their release, free photons were fast rotating gears of an electromagnetic apparatus invading the universe at different coexisting scales of complexity. To model this behavior, a generalized set of equations describing electromagnetism has been developed. The aim is to host under the same roof, both pure self-contained undisturbed waves traveling as bullet at the speed of light, and stable vortexes confined in specified regions of space. This achievement is obtained by interpreting electromagnetism in the same guise as an immaterial fluid, able to create robust configurations, technically represented in the easiest situations by electromagnetic *vortex rings* (we will return on this in section 4).

Starting from the deepest recesses of atom nuclei and growing with size, the background electromagnetic radiation ceases to be unnecessary noise to become

an active scaffolding able to keep together atoms and molecules, up to the chemistry of biological interactions. A tremendously large amount of energy normally flows between bare particles. These last remain however the principal responsible for the organization of their surroundings, by virtue of a spinning behavior that is transferred everywhere through contiguous shells, with angular velocities decaying with the distance. The construction is not just a way to decipher the secrets of the constituents of matter, but serves as a deterministic explanation for quantum phenomena, in line with known experimental data.

Moreover, matter is a kind of open system. With this we mean that sets of oscillating energy layers extend outside the presumed limits of an object (whatever its material, size and shape are) and cover the structure like an invisible neutral halo. Objects are bigger than expected and they are all connected. It is evident that massive matter is just a small part of this immense playground.

Objects and living beings are then glued together by a pervasive electrodynamical background, explaining why, by linking stages of increasing complexity, unities with new characteristics emerge from collecting smaller parts. The background is a continuum that connects various structures, but the two aspects are not independent; they actually have the same electromagnetic origin: matter can be destroyed becoming part of the background; energy of the background can give birth to matter. If we assume that the constituents of matter are just the massive parts (electrons and atoms nuclei), we end up with nothing in our hands, since these objects are so small in volume to account for a 1/1000000000000000th of the total span (of a piece of iron, for example). There is something in between that makes solid objects compact and resistant. What we actually call "matter" is the union of inseparable entities. To this regard, we would like to cite the following paragraph extracted from [8]: *Each of us is a quantum entity entangled with a quantum photon field and both represent our individuality. The quantum entity is purely matter and localized while quantum field is purely energy and spread far and wide. The matter part is considered living and energy part, non-living but both contain equivalent amount of information about various aspects of 'life'. The two parts remain tuned with each other; any change in one part, is instantly reflected in the other part as well.*

In conclusion, nature is not a crude mechanical interaction of lonely subjects. Things are unavoidably interconnected and the only way to understand their functioning is to conform to a holistic vision. The construction sequence starts at the atomic level, but at certain stages of development the geometry can be mediated by larger clusters. Therefore, it is not possible to refine the knowledge at the upper level, if one does not take into account the myriad of intermediate passages. The universe turns out to be a continuum composed by independent quantized nested electromagnetic entities, evolving and changing with time according to specific rules. Clearly, such an interpretation is rich of philosophical implications, that may intrigue some attentive readers.

2 Snowflakes

Snowflakes are amazing crystal structures, whose creation is at first sight mainly influenced by the temperature and humidity of the atmosphere. It is well known that they grow by displaying a multitude of magnificent shapes. Evidently, the specific topology of the water molecule has a primary role in the process of joining together the various pieces of the tessellation. Nevertheless, the construction is not as straightforward as one may imagine and presents aspects that still needs deeper investigation. Of course there are already numerous mathematical models that try to replicate snowflakes growth (see [9], just to mention a recent publication). The problem remains however unfocused, at least for what concerns the points that we are going to outline in the paragraphs to follow.

According to [10]: *The inherent complexity of the physics has resulted in a rather large gap between the basic tenets of crystal growth theory and the phenomenology of growing practical crystals.* Algorithms modeling fronts evolution through the reproduction of hexagonal type stencils, and theories that allow for the numerical simulation of single dendritic components, are well grounded and quite efficacious. There is however a blurred area when one tries to understand the simultaneous and autonomous growth of six independent branches of a flat dendritic type snowflake. Since a crystal has commonly the size of about a millimeter, the one-dimensional path between the tops of two consecutive branches may count on a number of the order of ten millions intermediate molecules. If the exchange of information between particles only involves neighboring entities, it is hard to believe that the unavoidable accumulation of errors does not negatively influence the final product. The process of formation of the dendrites can in principle follow an outrageously huge number of combinations, thus an imperfection occurring in one branch may result in a total destruction of symmetry. Yet, a sort of spread communication organizes the crystal growth in such a way that, what is happening along a single branch is almost perfectly cloned along the remaining five. It is impressive to observe that, even if this cloning process may show non negligible errors here and there, the outcome looks however extremely symmetric, as if an impalpable direction was governing some underlying "project". Parts of the design may be slightly dissimilar, and this is probably the more striking feature. These differences could have resulted in an alternative evolution of a dendrite; instead, the whole crystal is realized with an incredible regularity. Another nontrivial aspect to deal with is that related to the intrinsic dimension of a snowflake. In fact, the growth process seems to be limited in size (there are no one-meter wide snowflakes, though theoretically this would be not forbidden). The capacity to share information between the dendrides fades fast as they increase in magnitude, and this is not an obvious consideration.

Let us try to provide an explanation to the above mentioned mysterious facts, according to the viewpoint that molecules tend to occupy regions of space that go beyond their natural bounds dictated by Van der Waals radii. For simplicity, and to avoid censures, we do not enter into the merits of the consti-

tution of an atom. The reader interested to an unconventional construction is addressed to [2]. When we immerse an atom in the electromagnetic ocean, the consequences of its presence are communicated outside its boundaries. This is certainly due to stationary electric and magnetic effects, but also (and specially) to the continuous spinning of the fields around the nucleus and the family of electrons. Each atom has its own internal electromagnetic fingerprint, and we can check this in practice by stimulating the structure, so to provoke a release of energy under the form of photons. There is no need of big instrumentation, since objects exposed to sunlight already scatter all around an enormous quantity of photons, whose energy ranges from that of visible light up to X-rays. The theory proposed in [2] claims that photons come from the breakage of rotating electromagnetic shells already encapsulated within the atomic "body" (and not, as naively explained, from the electromagnetic waves released by an accelerated electron changing its trajectory).

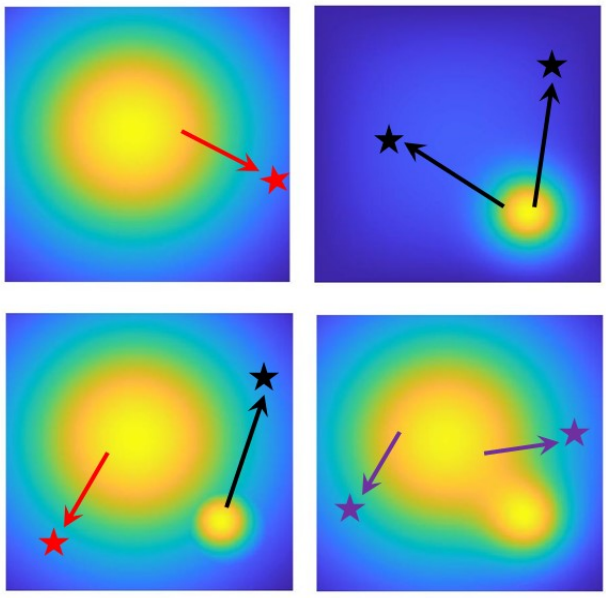

Figure 1: The close interaction of two objects (pictures on top) does not correspond to the union of their bare parts (third picture), but generates a new entity (fourth picture). Masses and charges sum up linearly. The "emergent" body has however a different distribution of the electromagnetic shells and, under stimulation, emits photons (colored stars) in a new energy range. It is very important to remark that the patterns schematically displayed above are not the trivial countour levels of an electric potential. They indicate the boundaries of a series of encapsulated domains, inside of which electromagnetic fields dynamically modify their orientation, so giving the impression of a physical rotatory motion.

Through a kind of reiterative process, around the atom, other shells tend to be generated. They have little energies that decay with the distance, so they may not be clearly noticeable by instruments. Nevertheless, these external circulating photon shells are there to allow the atom to "talk" and let the world know what are its peculiarities and preferences. Chemical reactions and bonds are the practical realizations of such a predisposition, when appropriate circumstances are met. In this perspective, reactions are not only ruled by randomness or simple Coulomb interactions, but are consequence of a direct response of active parts, that prearrange the ground for possible aggregation or disaggregation. A new formed molecule has the same amount of massive components (nuclei and electrons), but displays a rather different electromagnetic shell configuration. The main consequence of this results is the celebrated statement:

The whole is not the sum of its parts.

The composed structure may "resonate" at specific frequencies and emit photons that are not those of the single isolated elements (Fig. 1). These electromagnetic emissions are indeed used in applications to recognize chemical elements.

The passage from molecules of the same type (water) to the crystal, happens according to the same principles mentioned above. For instance, as practically documented in [2] and [11] through many mathematical examples, it is possible to create waves surrounding objects. These do not radiate, but transmit energy information in a circle by mimicking a sort of Mexican wave. Stationary fields may be optionally added to the whole contribution. The primary consequence of this interpretation is the non-heterogeneity of the surrounding space, even in the case of a single symmetric charge. A new element entering the range of an already consolidated family is driven by invisible forces, that provide for the mise en scène. As we said, local forces are important but are not the sole ingredients. The arriving molecule encounters the electromagnetic "halo" of the existing incomplete crystal before creating a real chemical bond. In doing this, the whole environment is deformed, becoming substantially dissimilar, just because the preexisting bulk plus the newcomer molecules is not the mere union of the independent parts. The information is transmitted all around via the encircling shells and the change affects the arrival of other new molecules (see the bottom picture in Fig. 4). The coordinate allocation of elements that are very far apart is achieved by using the electromagnetic background as a medium for transferring information. The response is fast since everything develops at speeds comparable to that of light. The final settlement is constrained both by the geometry of each single water molecule and the realization of a global displacement that tends to minimize the energy of the entire system of shells. As also explained in the caption of Fig. 1, we are trying here to describe a phenomenon that is far more complex that the crude representation of a static charge density or other potentials, as suggested in [12].

A theoretical study, still to be developed, should be based on a proper definition of certain energy functionals, also taking into account that magnetic fields play a primary role. This is true not only regarding the intensity, but

because their closed lines of force may be naturally put in relation with some spinning like behavior, with a corresponding breakage of the heterogeneity of the space. We are a bit hesitant to claim that the present approach may fully explain the astounding look of a snowflake, but we feel that the analysis of this mechanism could be a step towards a better comprehension of the phenomenon of ice crystals formation.

3 Catalysts

So far, we just examined inanimate entities. The discussion has been however approached in a way that allows for systematic generalizations. Let us stay again for a while with water. Liquid water is omnipresent on Earth. It is actually the most abundant element in living cells. It is not just a necessary filling medium, but, as reminded in [13], takes an active part in the functioning processes, especially with the role of transmitting information. The interpretation however requires clarifications. Even in the liquid state, water molecules enjoy very little freedom. They are not close enough to give rise to strict links, however the internuclear distances remain in the range of tenths of a nanometer. Due to the lack of room, we end up with the conclusion that the movement should be only restricted to mechanical deformations. Physical shift of a single molecule for relatively high distances is almost out of question. This does not prevent the deformation of large volumes, in the typical fashion characterizing viscous fluids. Since we are dealing with charged entities, one can also invoke reciprocal exchanges at electrodynamical level. Nevertheless, as long as we restrict our discussion to stationary (or almost stationary) forces, screening effects are definitely not negligible. Indeed, due to the close packaging, atoms have no chance to glimpse each other. Any two elements are obscured by the electric barrier of the intermediate ones. We are left with two other possible ways to communicate. The first is the one we are trying to promote in this section, that fully employs electromagnetism through the interactions of waves trapped into suitable shells. The second, that will be specifically discussed in the next section, is based on the release or the absorption of photons coming respectively from the breakage or the reconnection of the previously mentioned shells.

In Quantum Mechanics, where particles are preferably seen as wave-packets, the transmission of electromagnetic information in solids (including electric conduction), is explained by introducing quasi-particles called *phonons* (see, e.g. [14]). In a crystal lattice, waves floating within the structure carry messages and energy from one side to another without necessarily involving the motion of massive electrons, which may remain in the regions assigned to them by the atomic displacement. Phonon packets propagate at high speed inside a medium with very little distortion and have an important role in redefining thermal and electrical conductivity. It has to be said that these entities do not really exist in nature outside matter. They are theoretical byproducts created with the purpose of providing a quantitative evaluation of the energy transport inside matter. In the context of photon shells, phonons can still be idealized, with

a different meaning however. To us, an atomic structure (of any complexity in principle) is a set of neighboring electromagnetic balloons of various sizes and shapes that, when stimulated, carry information through a chain process of "elastic" deformations, which also include acts of creation or annihilation. Since no masses are involved, the transfer can happen at high speeds and without destroying molecular structures. The concept of phonon is still latent, but at least we are dealing with real physical entities, although just made of evanescent electromagnetic fields. We do not deny that an effective electron shift can also take place, as a rare circumstance by the way.

The insertion of a non-water molecule into water alters the general equilibrium of the preexisting system of shells. The effect may propagate well beyond the closest neighbors, and does not necessarily involve the dislocation of atoms. The crucial hypothesis is to assume the existence of a pervasive electromagnetic background and the possibility that this may be suitably altered by the presence of true atomic particles (electrons and nuclei). Without this physical environment, other explanations become illusory, such as the questionable introduction for example of purpose-made quasi-particles. These observations allow us to reflect about the functioning mechanism of *catalysts*.

A catalyst, even in small quantities, is able to increase a reaction rate without being a direct part of it. The reactants are invited by the catalyst to speed up their process within a prescribed spatial range. Explanations of this phenomenon are mainly based on thermodynamics arguments. According to our opinion, "temperature" is not merely linked to the state of agitation (or disorder) of the reactants, but more properly to the energy of the system of photon shells of the whole substrate. The presence of a single catalyst would be able to deform the environment up to a certain distance. Reactions are then favored by a direct modification of the habitat. Such a change is structural and not associated with the higher probability of encounter of the reactants. It is not the position of the atoms to be modified, but their capability (driven by the catalyst) to destroy old bonds and create new ones. In other words, the union of a catalyst and a certain number of nearby reactants is not the sum of the parts. It is a new entity corresponding to a local alteration of the electromagnetic background. Such a reorganization of the shells patterns has the property to link objects in a different way.

The above interpretation becomes more significant in the case of complex molecules such as *enzymes*, especially for what concerns *ligases*. In the "lock and key" model and its variants, the elements of the substrate reach the enzyme and look for an appropriate allocation. If the connection is correctly done, a reaction takes place. The iconography of such a procedure is known to everybody (see Fig. 2). The drawing of the enzyme is represented with two openings (A and B) of rather different shapes. External molecules are processed only if they have the right match. This representation is very explicative, but in our opinion is a source of misconceptions. Indeed, as already specified, the catalyst and the reactants are not isolated bodies. They are in general immersed in a dense broth of other molecules that may largely vary in typology and size, and this

is particularly true inside a living cell. The packaging is stringent and does not allow for easy migrations. In addition, reciprocal electric screening effects, due to all the charges involved, generate a sort of fog. In this misty habitat, a key molecule of type A must "sniff" the presence of the lock of type A in the enzyme. Attracted by a not well specified impetus, A jams into a sea of adverse forces until it reaches the final location. With the assistance of the good luck, A will find the companion molecule of type B. As the marriage is done, AB must go away, crawling into the crowd, in order to leave as fast as possible the site free for another couple. As one can imagine, this mission is impossible and cannot be ruled by randomness, also if we think in terms of an incredibly augmented number of probabilities due to the enzyme presence. Brownian motion effects cannot be invoked, since they look too generic, too elementary and terribly slow. So, what happens then?

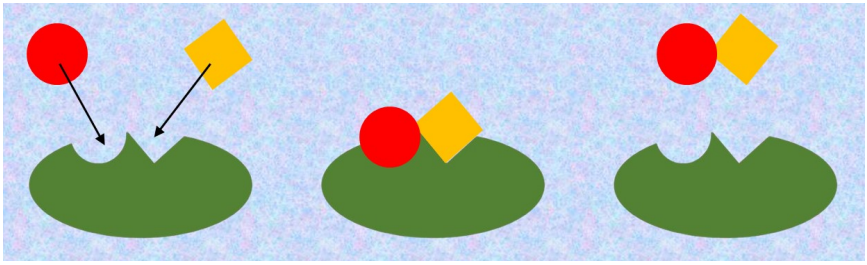

Figure 2: Roughly, in a ligand type enzyme, the elements of the substrate are swallowed and successively expelled after the reaction.

Our explanation resides on the fact that A and B are already relatively close to each other, but not enough to feel their reciprocal presence. In truth, there are many other As and Bs scattered all around. When the enzyme is introduced, the whole environment is modified (Fig. 3). The catalyst holds the right "codes" that determine (within a certain range) the reorganization of the photon shells, in such a way that, in the new configuration, the reaction between A and B is favored, and this may be true for many couples at the same time. The complexity of the enzyme is high in order to emphasize a selective process where A and B may stay well together, whereas this is not going to be true for other types of reactants. The big difference with respect to the classical approach is that the physical movement of the molecules is reduced and does not produce crowding. The electromagnetic environment relocates energy, by zigzagging across the atomic structures. Rarefied or compressed zones are distributed in the three-dimensional space according to prearranged schemes. These variations of energy density contain the paths along which specific chemical processes have more chances to occur.

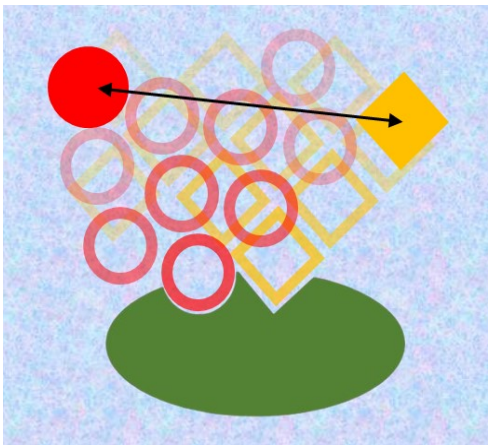

Figure 3: In the new perspective, the enzyme modifies the complex electromagnetic environment in order to make the reaction more favorable. No direct contact between the enzyme and the reactants is now necessary. Note that the guiding patterns are not stationary. They dynamically stimulate the background, conveying information here and there in a very distinctive manner.

Enzymes are *proteins* constituted by a quantity of *amino acids* (up to 500, and more). At the first level, their formation is regulated by extremely simple and repetitive chemical bonds. As we suggested in the case of a snowflake, the components may communicate at large distance, inducing the macro molecule to mechanically assume a three dimensional shape in space. It is straightforward to guess that such a folding strictly depends on the type of amino acids taking part in a prescribed chain. The extraordinary fact is that we have here a new type of emergent situation. A *denatured* protein is already expected to be more than the sum of its single chemical parts. Nevertheless, we have additional features, if we consider that a folded protein retains more information than its unfolded version. Indeed, in the case of a folded molecule, the electromagnetic background is modified by allowing for alternative links between the shells, so to create new structures "resonating" in a different fashion (see Fig. 4). As an infinitesimal crack changes the typical sound of a bell, the rupture of these new electromagnetic connections may alter the capacity of a protein to perform its tasks. The region of space occupied by a folded protein guarantees the rigidity of the scaffold and, at the same time, provides the protein itself for the functional properties that such a macromolecule is expected to support. In addition, we observe that it is not just important to bend, but how this should be done. From the same yarn we can either get a wool ball or a knitted cap, but the two resulting objects clearly do not have the same potentialities. It seems however that for proteins we have less choices, since we cannot generate a "cap" with the incorrect sequence of amino acids.

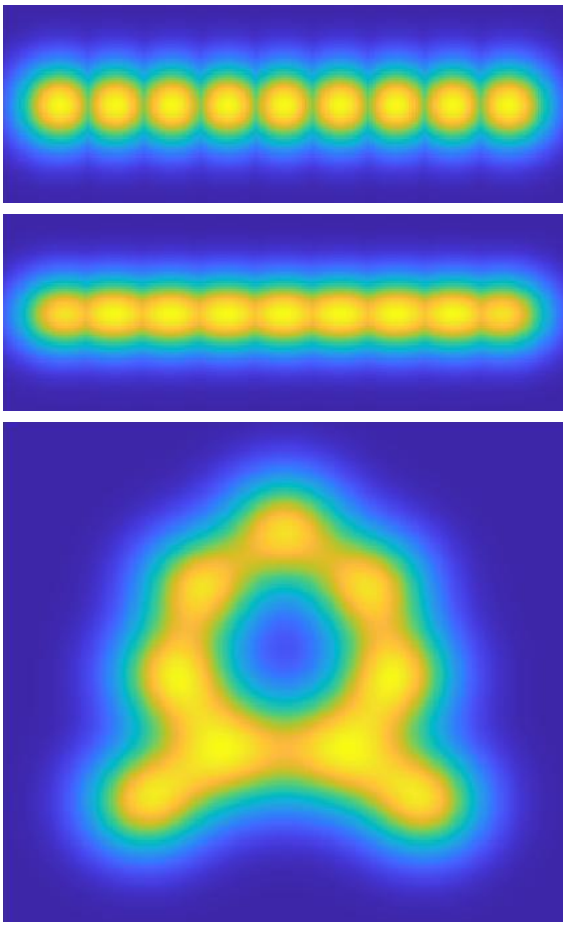

Figure 4: A series of isolated amino acids (top) contains less information that the corresponding denatured protein (middle). Nevertheless, in the folded protein (bottom), where new chemical correlations are present, the dynamical structure of the shells systems becomes more complex. The background is topologically structured in a different way and the electromagnetic waves connect the ingredients following alternative paths. The frequencies involved are totally dissimilar if compared to the unfolded version. The modification impacts on the whole environment, within a range that may be relatively large. The above pictures are static snapshots of a kinetic evolution involving an intense exchange of electromagnetic information around single amino acids, groups of them, the entire protein, and well beyond.

We can try to make a comparison with an old style cathodic-tube TV set, where the global 2D image at a fixed time is represented by 625 horizontal lines. Of course, we can study the signal obtained by putting all these lines one after the other, which corresponds to a long string. Unfortunately, in this way, we

miss the 2D interpretation, though we can still play with the string. Well, the same can be applied to an unfolded protein. Only the entangled 3D version can provide an idea of what really happens. Again, the protein is not the sum of its amino acids. It is a complex electromagnetic structure that performs in the right way only when it is properly folded (see also the comments in the caption of Fig. 4). It is the union of the chemical constituents and, at the same time, a very characteristic deformation of the electromagnetic background. As in TV fiction, the scenery is in continuous evolution. The pictorial representation of a given protein in this new framework is not the typical ornamental ribbon, as commonly shown in books. It is more properly a solid three-dimensional grain displaying individual peculiarities, and representing one in a billion of possible diversified little bricks. Moreover, the huge number of bricks making up a living organism are not however isolated like grains of sand on a beach, but they are electrodynamically active and communicate through the omnipresent background. Proteins are not inanimate as a stone. They have a structure and an energetic part (a body and a soul; see also the citation at the end of section 1). Technically they cannot be classified among "living entities". They are at the beginning however of a long path, that will continue with their aggregation, finalized to the assemblage of further emergent situations.

This is not yet the end, however. We have another important ace to play. The electromagnetic energy, initially stored in shells may escape and travel in packets along direct paths. In fact, a shell may break and free the corresponding photon. This goes almost straight, like a bullet exploded from a gun. The same photon may encounter an appropriate "receiver" and be entrapped again. We discuss this phenomenon in the coming section.

4 Biophotonics

Our viewpoint, shared in part by other eminent researchers, is that biological processes are not just the byproduct of crude chemical reactions. There are fastest ways of communication, where photons travel at velocities close to that of light, passing almost undisturbed through atomic structures. We can actually catch these signals and this is the main goal of a discipline called *biophotonics* ([15], [16], [17], [18], [19], [20]), which is related to the study of optical processes in biological systems. Since the pioneering work of F. A. Popp ([21], [22]), the interest for this subject has grown exponentially. Photons carry energies that are very diversified depending on the context. A sort of frequency can be assigned to them, which in first approximation has an inverse relationship with the size of the emitting object. We can start from tiny atom nuclei and their release of *gamma* rays (lengths are of the order of 10^{-15} meters). As we move a little far from nuclei we enter the range of X-rays. Entire atoms (we are now in the range of nanometers) emit lights from the infrared to the ultra violet. For a review of the more relevant phenomena in this field, with a rich list of references, we suggest [23]. For a collection of papers on *photochemistry* and *photobiology*, we cite [24] and [25].

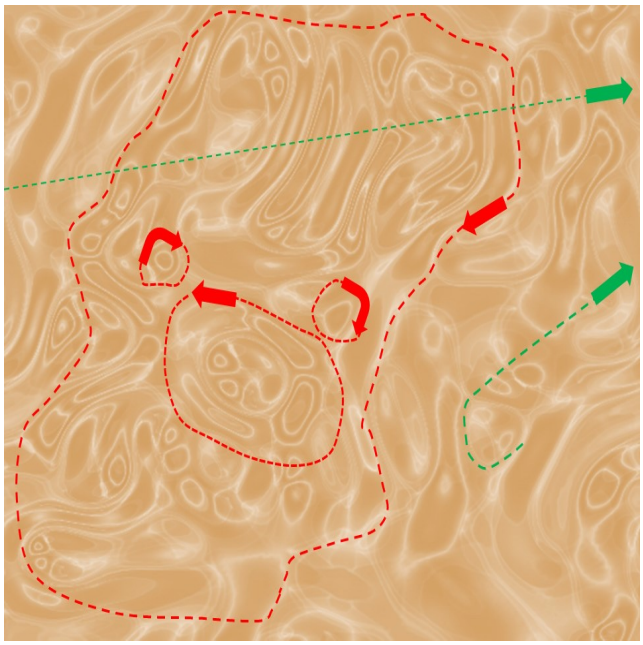

Figure 5: Electromagnetic signals circulate, encircling objects of increasing magnitude, so forming clusters displaying new properties. As a rule of thumb, the angular velocity diminishes as the size grows. Some balls may collapse becoming free photons, that escape in open space or, if the circumstances are favorable, become gears of another structure. Everything is connected and things are diversified by being members of different communities .

We would like to point out that our concept of frequency is not the one suggested by Quantum Mechanics, where waves having no physical dimension are attached to any moving body and are often related to distributions of probability. This conceptualization is not in line with the purposes of this paper. Indeed, our construction gives rise to a "real" assembly of the environment. The predictions of Quantum Mechanics are proven to be experimentally correct. Nevertheless, our "bare" photons are not expected to have frequency. They are compacted peeks, traveling as bullets. They can have in principle any size, therefore they are not infinitesimal. They are not the *carrier* of the electromagnetic radiation (this notion is indeed quite abstract!). They are entities behaving as "particles" and, at the same time, an electromagnetic message is imprinted on them. The theory in [2] fully covers all these aspects in the framework of classical electromagnetism.

An idea of frequency may be retrieved if we suppose that, before becoming "free", photons were encapsulated in some region. Since electromagnetic entities have an innate attitude to develop at speeds comparable to that of light, we can now suppose that small objects can be associated with high frequencies, and vice

versa, larger objects are well suited for the low frequency domain. For example, a cell is a huge body when compared to its basic chemical constituents; therefore, it emits or absorbs photons in a lower "frequency" range (see later on). We can also expect a direct relation between the electromagnetic energy of a photon and the frequency it represents, although for us this is not a strict rule. Therefore, the association frequency-wavelength is straightforward in our context, whereas the association frequency-energy should be pondered with more attention. We prefer not to add here further comments on this issue.

Figure 5 offers a extremely simplified 2D picture aimed at visualizing our interpretation of an electromagnetic universe. An analogous scenery in 3D would be far more complex and mostly based on encapsulated electromagnetic *vortex rings* [11], whose dynamics is very similar to that of the more classical fluid dynamics analogs. The reader that has not confidence with such amazing structures may find a lot of informative material online. This fact-finding mission is highly suggested, since it will disclose an unexpected world of physical phenomena. In conclusion, we are assuming here that nature can count on an impressive amount of well-organized oscillating photonic energy. The conclusions of the analysis in [26] point out that the actual number of biophotons inside cells is going to be significantly larger than that expected from measurements. If ours is the correct view, it should be straightforward to deduce that the above features must have had an important role in the evolution processes of living entities [23].

Before proceeding, it is worthwhile to say something about *photonic crystals*. These periodic nanostructure are able to affect the motion of photons, similarly to what happens for phonons (see previous section) in crystal lattices. They contain periodic regions, alternating high and low dielectric constants. Photonic crystals may be handmade (see, e.g.: [27]), but they are also frequently found in nature. In the visible range, they provide coloration, as in the wonderful case of butterfly wings. Examples of such structures in animals are reported in many papers. We just mention a few references: [28], [29], [30]. This is not however the kind of application we are interested in, since our aim in this section is to study the role of photons inside a single cell. As specified so far, our analysis involves the two following main issues: an increase in complexity through successive layers in order to generate new emergent structures; the capacity to communicate through the ubiquitous background by the exchange of electromagnetic packets.

In a cell, the principal points of photon absorption and emission are in proximity of the DNA. This intense activity regulates the most fundamental biological processes. Through such an electromagnetic exchange, the DNA molecule becomes an active apparatus governing the transfer of complex instructions. Let us make some crucial observations. The human DNA is about 2 meters long. It is folded, then folded, and folded again until it reaches the size of a few microns. It looks obvious that its capabilities to work should necessarily conform to the final 3D configuration. Therefore, the unfolded DNA version tells us only a part of the entire story. Most of the DNA is of *non-coding* type. Apparently, this

dominant part seems not to have a role, although there is debate on this issue ([31], [32]). It could be surplus material, stocked during Darwinian evolution. Some research results show that it does influence biological processes somehow. Other experiments suggest that its partial elimination may not bring to radical changes, at least in first approximation. Perhaps, non-coding DNA is a bunch of garbage when examined in the context of a one-dimensional string, but assume a meaning and a functionality when examined in its natural framework. It is worthwhile to point out that the compactness of DNA is different from that associated with proteins. Actually, a protein is a finished building block. Once produced and suitably folded, it is able to do its job, and the knowledge of its constitution is not a priority anymore. In contrast, DNA is a recipe book. It is necessary to systematically read its instructions. Unfortunately, such a book is shut, and the access to the codes is far from being easy.

The *RNA polymerase* [33] is an enzyme designed to make copies of a DNA strand by producing new RNA filaments. These filaments are further modified and finally decoded by a protein called *ribosome*, which translates the messages carried by the *nucleobases* into real new proteins. Electron-microscope pictures obtained *in vitro* (figure 10-39 in [34], for example) show a large number of RNA branches emanating from an unfolded DNA strand, as the byproduct of the simultaneous action of many RNA polymerases, busy in their duplication work. This "physical interaction" is however unimaginable when the DNA is entirely folded, due to the total lack of extra space. *In vivo*, the situation is further emphasized by the huge amount of surrounding molecules of various types and sizes, most of them having no direct role in the reactions that are taking place. The discrepancy, due to the extremely different crowding levels, between what observed in laboratory and what is expected to happen in real life is detailed in some papers ([35], [36], [37]), and remarks the difficulty to get an authentic picture of the processes effectively occurring in a cell.

The inaccessibility of the DNA nucleotides is not the only problem. Indeed, the DNA parts exposed at the exterior of the folded molecule have far more chances to be replicated. As a matter of fact, statistically, an RNA polymerase is less prone to reach the impenetrable interior parts. This again excludes activities ruled by randomness, although it is known that the most used genes are available in multiple copies. In addition, each gene is composed by a variable number of nucleobases, that are characterized by a "beginning" and an "end", also coded in the gene sequence. In practice, the search for these limits is time-consuming and is driven by unclear mechanisms. Finally, all the building blocks of the newly generated RNA strand must be previously present within the immediate neighborhood. They have to wait patiently to be called in the exact order, without obstructing the entrance. After the assembly, they must be on their way as soon as possible.

The moral of the above observations is that functioning schemes based on the physical movement of molecules are unthinkable, contrary to what is shown in high-quality educational videos (see, e.g.: [38]), where intricate devices recalling Leonardo's machines, simulate molecular interactions inside an exaggeratedly

spacious environment. On the other hand, we know at this time that it would be sufficient to only convey "information", and that the data may travel fast, at relatively large distances and without encountering obstacles, through the electromagnetic background. In this context, proteins and other large molecules act as intermediate transmitting stations, receiving and distributing specific signals towards precise directions. They can occupy fixed positions and drive the assemblage of small amino acids from a distance. In these circumstances water may become an essential mediator. This approach looks intriguing, but needs to be supported by some constructive ideas. We provide here below some workable suggestions.

The objective is to globally view DNA as a sort of oscillatory electric circuit, as summarized for instance in [39]. From this standpoint, the entire DNA molecule is not just a static data container. This last aspect is the one that actually makes the difference with respect to the more consolidated view. The codes are not encrypted in the pair bases in relation to their intrinsic chemical composition, but on their capacity to process the signals dynamically. Deoxyribonucleic acid is a symphony played in real time, and not just a music sheet. Recall that, in the context of this paper, matter is a combination of tiny well-distributed particles and a sparkling foam of electromagnetic bubbles. With its atoms remaining almost blocked, DNA is a time-dependent electric machinery that repeats its information with the support of the *phosphate backbone* wires. The data can be in principle intercepted at any point along the track or, more likely, "radio" transmitted to other macromolecules. In the protein coding procedure, a triplet of nucleobasis corresponds to a single "note", which can stimulate a specific amino acid. The impulse does not reach the destination through a direct pattern, but is preliminarily translated with the help of intermediary checkpoints. Let us add further arguments in favor of such an atypical interpretation.

Results, both experimental and computational, confirm the conductivity of the periodic phosphate backbone [40], and the nucleotides ([41], [42],[43], [44]). Vibrational spectra of pair bases have been determined ([45], [46]), and their response to UV excitation is documented in [47]. The presence of nitrogen may confer to the compounds a natural tendency to flip from a configuration to another. This may be the case of nucleotides, that are in this way allowed to deviate from their planar geometry [48]. Moreover, the DNA wrapping around a *nucleosome* is compatible with magnetic lines of force along the cylinder axis (see the solenoid model of figure 8-25 in [34]). By putting together these scattered pieces of information we may advance a conjecture. According to our interpretation, the nucleotides impart to the electromagnetic environment, already in continuous turmoil, a further oscillating behavior. These oscillations are not of mechanical type, and there is no physical movement of electrons (so, no currents in the classical sense). The energy is naturally relocated through periodic patterns that strictly depend on a given nucleobase or a group of them. A photon shell pops in a place, but a new one grows nearby. The process can be either cyclical or translatory. The background energy is directly inherited from

the preexisting vacuum, and does not need to be further supplied. Indeed, spontaneous dissipationless currents have been observed in periodic structures such as graphene [49]. Without stimuli from outside, the pair bases act as a series of *flip-flops* (molecular switches able to perform logic operations are examined for instance in [50] and [51]). All these little circuits are joined by the phosphate backbones, which collect the various oscillating data. Being each backbone a periodic filament, the flow of information travels in a way that recalls that of phonons (see previous section), therefore also in this case there is no electron migration.

In order to provide a partial support to the idea of a dynamical DNA, transmitting periodic messages according to the ordered displacement of the nucleobasis, we make a quite significant observation. Let us suppose to have a list of four symbols $\Gamma, \Delta, \Xi, \Omega$. We can consider all the possible triplets that can be formed using the above mentioned characters. Their total number is equal to 64. We then take the periodic signal generated by repeating indefinitely a given triplet. For example if we choose $\Omega\Gamma\Xi$, the corresponding "sound" is $\cdots\Omega\Gamma\Xi\Omega\Gamma\Xi\Omega\Gamma\Xi\Omega\Gamma\Xi\Omega\cdots$. The question is: how many different sequences can be built? First of all, there are 4 triplets $\Gamma\Gamma\Gamma$, $\Delta\Delta\Delta$, $\Xi\Xi\Xi$, $\Omega\Omega\Omega$, that generate trivial constant monochromatic sequences. We are left with other 60 (more interesting) situations. Let us now observe that the sequence descending from $\Omega\Gamma\Xi$ coincides with those generated by $\Gamma\Xi\Omega$ or $\Xi\Omega\Gamma$. This means that it is possible to group within the same "class" the three triplets producing a given sound. By dividing 60 by 3, we get 20 classes, i.e. 20 different possible sounds. Incidentally, 20 is also the number of amino acids, and such a coincidence is a bit astonishing. Of course, the first attempt is to check whether there is any affinity between the generic symbols $\Gamma, \Delta, \Xi, \Omega$ and the classical ones representing the nucleobases A, C, G, U, but it is soon evident, from the conversion table associating each *codon* with the corresponding amino acid, that a direct link is not recoverable. Nothing prevents us to think however that, the "electric circuit" constituted by a specific codon oscillates and produces, through a mechanism still to be detected, one of the 20 characteristic sequences, aimed at stimulating a specific amino acid. By this approach, the codification chart (codon $\rightarrow$ amino acid) is automatically imprinted inside each transmitting circuit, and is not part instead of the ribosome. In fact, the information is not the codon thought as a mere list of three symbols, but one out of 24 periodic messages (20+4, including the single-frequency ones) that a codon machine can manufacture. In other words, the symbols A, C, G, U have to be understood as a set of parameters, suitably triggering an electric circuit with the purpose of producing sounds composed by the notes $\Gamma, \Delta, \Xi, \Omega$. As a final remark, we observe that there are 12 sequences in which a given symbol is duplicated (for example: $\cdots\Delta\Delta\Gamma\Delta\Delta\Gamma\Delta\Delta\Gamma\Delta\Delta\Gamma\Delta\Delta\cdots$), and 8 sequences where the symbols are all different. It might not be an accident the fact that there are exactly 8 amino acids (namely: Leu, Val, Ser, Pro, Thr, Ala, Arg, Gly) each one represented by not less than 4 redundant codons (actually Leu corresponds to 6 different codons).

The *structured* non-coding DNA assumes at this point another identity: a repetitive meaningless sequence of characters becomes a prescribed wave, displaying a shape that depends on the string length. Fragment of whistles of different frequency and duration punctuate the DNA, interlaced with protein coding instructions. Other surreptitious pieces can occupy fixed positions (*introns*) or change their site during duplication (*transposons*). Such distinguished impulses, when suitably emitted in the guise of biophotons, may be discerned from others circulating around. Possibly, they can also travel out of the nucleus and the cell. What is their final destination? There are many possible targets. We do not have to forget that the genetic tracts of different individuals are reflected by the diversity of the respective DNA organizations, especially for what concerns the location and the type of the non-coding sections. The correct assembling of proteins is a fundamental task, however the specificity of any single organism goes beyond the knowledge of the basic building blocks. This discussion may find roots in the framework of *epigenetics* [52]. Thus, the non-coding DNA could actually be decoded, and tells us about the most interesting peculiarities of living beings, i.e. their ability to reproduce and interact with the exterior world.

5 Impact on everyday activities

Going back to biophotonics, another frequency band of interest is the one around Terahertz (1THz=10^{12}Hz), i.e. between radio frequencies and the infrared spectrum. For a review on measurement techniques we address the reader to [53]. In perfect agreement with the fact that large objects resonate at lower frequencies (as we know very well from sound phenomena, for instance), biophotons in this range are commonly related to emission or absorption from entire cells. Extensions to tissues or even entire organisms are also taken into consideration. With light, it is also possible to visualize biochemical constituents in action, so that to learn in real time about the dynamics of certain processes. Most of the applications are in the medical field, through the study of the reactions of cells under laser stimulation. It seems that the correct functioning of a living organism relies on the proper circulation of biophotons stored in the cell. With these premises, it is possible to discriminate between healthy or cancer cells from the differences in the spectra of biophoton emissions. The hope to develop such technologies in the framework of real clinical practices has good chances to be realized in the near future.

Once again, we recall that the model of interactions that we are analyzing in this paper is based on two basic principles. The first one concerns the transmission of properties belonging to neighboring entities, obtained by sharing their electromagnetic environments in order to form new, and increasingly more complex, emergent entities (a snowflake, for example). The second one is the fast communication between the single parts, through the mediation of photons (as those received by our retina, successively converted into signals traveling along the neurons and finally reaching the brain, perhaps again in the form of pho-

tons [54]). The two aspects are rather different, but they often come together in nature, so that it is difficult to make distinctions in practice. A living being is so intricate that all the possible means are indispensable. More correctly, both the above mentioned expedients were already available, and Darwin's evolution optimized the resources. According to [55]: *Collectively, even the simplest forms of life, such as bacteria, reorganize themselves by gleaning relevant latent information embedded in the complex environment and pave the way for the evolutionary path that gives rise to other and even higher organisms.*

In the review paper [56], some phenomena are collected in which cell-to-cell communications can be established via non-chemical and non-contact means. According to [57]: *Cells are also capable of non-linear cell-cell communication independent of diffusible factors, neural pathways, or other traditionally recognized pathways.* The study of the presence of "radiations" affecting various biological processes dates back to about a century [58], and earlier. The literature is rather vast, so we limit our reference list to just a few titles. Some papers among many others are for instance: [59], [60], [61]. By comparing brain activity of patients in the state of wakefulness or unconsciousness, different types of noise are measured, as reported in [62]. This suggested the authors the conclusion that noise is not just a background but may be considered as a means to convey information. The role of vacuum as a medium of memory storage for the brain is examined in [63]. As a further example we observe that biophoton emission in insects varies during metamorphosis [64]. We finally mention *optogenetics*, which is a technique that uses light to control genetically modified neurons (see, e.g. [65]). An up-to-date discussion concerning the links between physics and biology is found in [66]. There, in the introductory section, a crucial topic is set forth, namely *figure out how animals and plants encode their physical shape.*

The capability of a single cell to interact straightly with the environment is overwhelmed by the capability of unions of cells to gather information and react accordingly as a unique ensemble. Passing through examples of growing complexity, this is true for all the activities where the general accomplishment is ruled by the entire group, even if the participating entities have an independent individuality. In order to do so, cells can either share information through the electromagnetic halo they are embedded in, or in the form of a rapid exchange of signal packets (the two options do not exclude each other).

A transmission mechanism we would like to mention is that connected with the perception of odors (see e.g.: [67]). The human nose is depicted as a chemical laboratory, capable of analyzing and discerning a multitude of molecules. These can be hosted for a short time by a large number of *receptors* of several different types. After complex passages, the chemical samples are classified and encrypted into signals to be sent along the neurons. We have no objection concerning such a conversion procedure. By the way, we suspect that problems emerge during the first passage of this process, i.e. the approach of a particle to be analyzed in proximity to a receptor. The troubles are similar to those already pointed out in this paper. In typical circumstances, the density of particles in air is extremely rarefied, nevertheless we can still catch the scent of coffee very far away from

the cup. It is hard to imagine a mechanism that associates the sample with the right receptor via a close contact. By virtue of which attraction forces should this happen? Also a stochastic explanation is not reliable, and not affordable in reasonable intervals of time, especially in situations of low density. Thus, we are more inclined to think of a sort of action at a distance, where each sample modifies the electromagnetic background in a very peculiar manner, similarly to what happens with enzymes. The action radius of the single molecule becomes in this way far more large and the sensor is then able to feel the variation. Such an interpretation also solves the problems due to possible overcrowding around the receptor. Indeed, once analyzed, a sample molecule should leave the site as soon as possible without coming into conflict with other particles (including molecules of oxygen and nitrogen present in the atmosphere). In fact, the receptor must be liberated in order to be promptly available for a successive scan. This is only possible if direct contacts are avoided to the greatest extent.

Similar arguments apply in the case of other processes involving the transfer of information by means of macromolecules, such as for instance *hormones*. It is well known that ants feel the presence of *pheromones* scattered along a trail. Certainly, they do not look for them by "looking" at them (those particles are too small), but they "sense" the dissimilarities of the habitat due to their presence, using suitable receptors. Again, we have two possible ways to explain this scenario. In the first one, pheromones surrounded by their electromagnetic halos are enchained within an organized network forming an invisible path. In the second interpretation, pheromones are transmitting standpoints, emanating biophotons in specific directions. Both implementations are justified by the same mechanisms hitherto discussed.

Another crucial topic is that concerning the existence of large electromagnetic environment surrounding us. As already stressed several times in this paper, the process is governed by a very extensive range of frequencies, inversely decreasing with the magnitude of the objects involved. For the reader's sake it is worthwhile to recall once again what we mean when we say that the electromagnetic frequency decreases. This aspect is not addressed to photons, which actually preserve their energy and somehow retain some frequency-related concept. The idea is referred to the system of shells surrounding matter. There, the angular velocity of the traveling signal is inversely associated to the size of each shell. An observer placed in a fixed position is able to appreciate variations of the electromagnetic habitat, whose periodicity varies depending on the location of the object generating the disturbance. The circumambient "tone" perceived is acute if the responsible object is nearby, and grave far from the source. Note that this has in principle nothing to do with the emission spectrum (if any).

Magnetohydrodynamics is a branch of physics dealing with the study of the magnetic behavior of electrically conducting fluids, where plasma is the most remarkable example. Applications in the field of astronomy ([68], [69], [70]), can help describe the constitution of the Sun and the solar system, by comparing the interplanetary medium to a fluid presenting magnetic properties. The study reveals a complexity of electromagnetic type structures filling up our solar sys-

tem, as well as the interstellar space. Just to mention a couple of examples, we may quote the *solar wind* or the *Van Allen belts* surrounding our Earth. *Space weather* forecasts is a branch of *heliophysics* that studies time varying conditions of the plasma within the solar system. The main applications are devoted to the preservation of electronic devices on board of spacecrafts or artificial satellites, but also to prevent the overexposure of human bodies to the harmful effects of radiation. In the light of these considerations, the interplanetary and the interstellar "vacuums" assume a conformation similar to that here attributed to this term. In [71], a structured model for the heliosphere has been proposed where the Sun is surrounded by a sequence of electromagnetic bubbles, whose size grows geometrically. Coincidentally, as one can easily verify, also the averaged radii of the planet orbits roughly follow a geometrical progression. This connection suggests that deeper links could be established between the heliospheric plasma and the classical mechanics of moving bodies. As a consequence of this interpretation, the entire solar system turns out to be a huge container of sparkling electromagnetic manifestations accommodating a few infinitesimal planets. We expect that this construction has had (and still has) a role in the development of forms of life on Earth, also by virtue of the fact that our globe, that follows an elliptical path around the Sun, does not maintain a constant distance. Thus, the oscillating behavior of the plasma may substantially vary, in frequency and intensity, during the course of a year.

Many occurrences happening in nature are repercussions of the feeble balance of very strong electromagnetic forces. Almost imperceptible traces can be documented, showing the interaction of our everyday activities with the periodic alteration of the electromagnetic habitat. The influence on biological activities of cyclical behaviors occurring in the universe has been treated by many authors. We address the reader to the vast literature on *circadian rhythms*, for instance, and their impact on cell division. If the resultant fields may be considered negligible for living beings of the size of a human, the same is not true when dealing with cell structures. The contingency may be particularly emphasized during the process of *meiosis*. The parent chromosomes are recombined according to their respective genomes. However, random fluctuations coming from the electromagnetic environment might contribute to genetic diversity. The same observation holds true in the case of viruses, that find advantageous situations for attacking a cell only when the habitat is favorable. This means that some evolution factors are subjected to the fortuitous state of the environment at very large scales. Explanations are not exclusively grounded on trivial climate changes or other classical environmental aspects. Indeed, our planet is a microscopic pebble at the mercy of strenuous forces. Species evolution cannot be extraneous to time changes of the cosmic scenario.

6 Final considerations

All the circumstances discussed so far assume a coherent meaning if we suppose, as suggested in the present paper, that the whole universe is an electromagnetic

bouillon, and that aggregates of matter of growing complexity can have an influence on such a medium. Each element evolves with a proper clock, depending on the scale of magnitude. Objects are interconnected, but the transitions do not follow smooth paths. There are barriers (see Fig. 5). A carbon atom has its own ball that is surrounded by a larger one when the atom is part of methane, and gets far more involved in the case of a polymer. The frontiers are however movable. They can also disappear and maybe reconstituted in another portion of space. Each level is not necessarily aware of being part of larger organizations (a single bird and a flock of birds, for example). These properties also include the most basic bricks of matter (electrons, protons) and anti-matter (positrons, anti-protons). Actually, the close encounter of an electron and a positron can give rise to pure photons in the form of gamma rays. Conversely, couples electron-positron can pop up from the vacuum.

Our understanding of the events of nature adds a new dimension to scientific knowledge. The characterization of a molecule through a crude formula does not tell us about the entanglement of the electromagnetic fields at the interior of the atomic scaffolding. Successive stratification allows for the creation of more evolved structures, that are not only the union of their tiny charged particles, but contain flows of energy channeled along very distinctive patterns. Growing with complexity, we may cite [72] by saying that *the morphology of living things transcends the laws of physics and chemistry*. In truth, with the slight revision of the electrodynamics laws introduced in [2], there are good chances that physics is able to explain most of the phenomena here examined. In conclusion, we are claiming here that everything turns out to be inevitably connected. By this assumption, it should be evident that if something happens in some region, sooner or later the effects will be felt elsewhere. This explanation goes far beyond the mechanistic one, and winks at an holistic concept of the universe.

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