

Article

# Getting Philosophical: On the Problems in Physics, Neuroscience & Biology

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## Abstract

In this article, I summarize what I see as the basic philosophical problems of the recent conceptual framework of biology and neuroscience and discuss how TGD can resolve these problems. Since one cannot actually avoid the problems of fundamental physics and of consciousness theory, so these are discussed to some degree.

**Keywords:** Philosophy, physics, neuroscience, biology, TGD framework.

## 1 Introduction

This article was inspired by an FB discussion and is an attempt to summarize basic philosophical problems of biology and neuroscience and the TGD based solution of them. One cannot actually bypass basic philosophical problems of recent day theoretical physics so that the discussion begins with these.

### 1.1 Importance of philosophical thinking

The FB discussion that motivated this article once again made manifest both the extreme importance and regrettable lack of philosophical thinking - not only biology but in natural sciences in general. I do not mean with philosophical thinking academic philosophy, which I have found mostly deadly boring. Rather, for me good philosophical thinking means posing critical questions.

What we really know and what we do not know? What do we believe and what part of this is just beliefs? Are there facts challenging these beliefs? What is consciousness: is it really a property of something as "-ness" suggests? What is free will? How it manifests itself? Is it an essential aspect of consciousness so that AI hype could be forgotten? Are free will and non-determinism really in conflict with physics as physicalist has decided to believe? Concerning consciousness, what guidelines come from modern, physics, biology, and neuroscience?

In physics critical thinking would have allowed to avoid the numerous fads and fashions that have plagued us during last 4 decades: GUTs that led to the wrong track, inflation theory, various ad hoc models of dark matter postulating some exotic strong AI, supersymmetry in its GUT form, superstring models, loop gravity,...

Critical thinking would have challenged various "interpretations" of quantum theory and we could have continued immediately the work of the fathers of quantum theory rather than waiting for almost a century. Critical thinking would have also inspired the question whether the non-determinism of state function reduction has something to do with free will and how one should generalize the ontology of physics (Copenhagen ontology gives it up altogether) to build a logically consistent framework.

Unfortunately critical thinking tends to lengthen the time spent in academic assembly line so that it is strongly discouraged. Thinkers tend also to become isolated from their social groups since everyone of us wants desperately to belong to some group and this requires sharing of its beliefs. It is easier to believe what professor and text book tell and get the research position and funding.

People are also very lazy. AI scientist decides that consciousness is running computer program or a property of the network structure or something equally ad hoc: no need to learn huge amount of

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physics, biology, neuroscience. Biologist decides that biology is nothing but Schrödinger equation and electromagnetism (or mere chemistry as in the older variant of the belief still prevailing). Neuroscientist decides that physicalism is correct and brain is the seat of the consciousness module. Brain as a computer paradigm makes the situation even easier. Physicist decides to believe in physicalism stating in its modern version that all physics reduces to Planck length scale: one can safely forget all other branches of sciences as a kind of taxonomy and specialize to apply one particular algorithm to build CV.

## 1.2 Basic dogmatics

The key dogmas common to all branches of natural science are physicalism and reductionism. Physicalism states that matter is all that matters and consciousness is mere epiphenomenon and that world is deterministic - in the quantum version of the dogma it obeys statistical determinism. Reductionist sees natural sciences as a victorious march towards shorter and shorter space and time scales. Science is an imperium that grows conquest by conquest.

We are told that super string theorists have taken the last step to Planck scale by building the only possible theory of everything. This step is really gigantic: from electroweak length scale there are 16 orders of magnitude to Planck length scale. Before this every order of magnitude has contained a lot of surprises but now the situation would be different as already GUT theorists revealed to us.

The surprise was however that the theory in Planck length scale does not allow to predict anything in long length scales: situation is like trying to predict the behavior of initial value sensitive system. The question of philosopher would be obvious: could something have gone wrong? This question has been made by some theoreticians. The decision of elite however seems to be that physics has reached its end. Nothing can be predicted and we should be happy about this marvellous feature of the only possible theory.

This series of conquests is marked by transitions. From biology to biochemistry, from biochemistry in vivo to organic chemistry in vitro, from chemistry to molecular physics, from molecular physics to atomic physics. Then follows a transition from atomic physics to nuclear physics: the assumption is that these two physics have practically nothing to do with each other. There are numerous experimental anomalies found during the last century challenging this belief. "Cold fusion" people were labelled next to criminals for their scandalous claims. Luckily the situation has now changed. But people talking about water memory belong still to the pariah of science.

After this jump we jump from nuclear physics to hadron physics to physics at quark-gluon level and then comes the really really big Planck jump. So simple.

There is however a little problem. Every successful conqueror must build a lot of bridges, without them the maintenance fails. Reductionistic conquerors were so hasty that they did not have time to build the bridges between these different physics. We do not understand how nuclear physics emerges from hadron physics emerges from quark physics. We do not understand how biochemistry emerges from organic chemistry emerges from molecular physics emerges from atomic physics. But we can decide that this is only a technical difficulty: if we had enough computational power we could fill these gaps.

## 2 Restricting the attention to biology and neuroscience

In the following the attention is restricted mostly to the philosophical problems of biology and neuroscience. It however turns that these problems are actually also problems of physics.

### 2.1 Nothing but biochemistry and electromagnetism

The basic dogmatics says that life is nothing but chemistry plus a little bit of electromagnetism needed to model cell membrane and neuronal membrane. There is also EEG but this is taken as noise due to neural circuits so that there is no need to waste time with it. Luckily, not all experimentalists know or

care about dogmatics and have found correlations of EEG with behavior and physiology and they are used as a diagnostic tool. Most of them however refuse to consider seriously the possibility that EEG might possibly communicate something from brain somewhere. Where would this somewhere could reside: outside brain?

No! Philosopher must be producing totally weird fairy tale now! Says the mainstreamer inside me with such a friendly but delicate tone that it becomes clear that he regards the poor philosopher as a screwball.

But philosopher continues asking. Didn't Libet discover that our sensory data is fraction of second old? Could it take fraction of second of this data to propagate as EEG signals from brain to this something. As a matter fact, Libet discovered also that the conscious decision to raise finger is preceded by neural activity starting for a fraction of second earlier. One cannot understand this unless one decides that it supports the absence of free will.

Philosopher asks also whether our decision that experienced time and the time of physicist are one and the same thing is be wrong. They are indeed different in many respects as any first year physics student understands. Should we trust facts instead of textbook wisdom? And what about Libet's second finding: could we give up our firm decision that signals propagate in only single direction of geometric time?

There is also a second strange electromagnetic phenomenon in biology: bio-photons. Already discovered almost century ago, they are still taken as pseudoscience by many biologists. They appear in visible and UV range but it seems that they are not produced in molecular reactions (this would mean peaks in the distribution). What is their origin?

## 2.2 Why vivo-vitro difference?

Even the basic dogmatist must admit that one must speak about organic chemistry in vivo and in vitro. In vitro one can build models for reactions, deduce estimates for the excitation energies of molecules, construct thermodynamical models for reactions in terms of thermodynamics involving parameters like activation energies and chemical potentials, one can develop complex networks of reaction pathways.

The typical assumption of these models is that everything is homogenous and isotropic: one has spatially constant concentrations of various reactions obeying differential equations determined by the kinetics. One can however construct more complex structure by allowing diffusion making possible spatial gradients.

The problem is that this dynamics has very little to do with what happens in living cell. The in vitro estimates for the rates of reactions are many many orders of magnitudes too low as compared to those in living matter. We do not understand anything about bio-catalysis. We know that enzymes and ribozymes somehow make the miracle but that's all. We do not have slightest clue about how reactants manage to find each other in the molecular soup full of different molecules. We have no idea wherefrom the reactants get the energy to jump over potential wall making the reaction quite too slow.

Philosopher would say that here is an excellent opportunity for new physics to enter in biology. How can reactants find each other? Could they possibly be connected by something, which shortens as the reactants meet? Could the notion of tensor network involving quantum entanglement be essential element of biology and entire physics. Particles would not be lonely riders but could be connected by something at least temporarily. Could this something liberate energy quanta allowing to get over the potential wall making reaction so slow? Could these networks have dynamical topology and make living systems what they are.

Unfortunately, standard space-time picture does not allow this something. Also Planck constant is quite too small. Should we conclude that the philosopher is weirdly fairytaling again?

## 2.3 What selected the biomolecules?

Philosopher also asks why only very few candidates for relevant biomolecules are actually selected. Who/what selected and how? This leads to very unpleasant questions circumvented by deciding that the emergence of life was nothing but a thermodynamical fluctuation. It has however become clear that complex organic molecules are present even in interstellar and intergalactic space. The miraculous thermodynamical fluctuation explaining evolution without real evolution would have been really huge.

Philosopher tends to conclude that we simply have no clue about what selection at the bio-molecular level really is and continue that some new physics is involved so that it is time to think giving up the reductionistic narrative.

The selection problem appears also at the level of biochemical reaction pathways. One can imagine endless variety of "reaction vertices". If one assumes that only very few basic "reaction vertices" are allowed but the rest not, one can construct a limited number of reaction pathways. But this is an ad hoc assumption: this selection of allowed reaction pathways certainly occurs but we do not have a slightest idea about the physics behind it.

There is also an analogy with computer science. One can construct endless variety of linguistically correct computer programs: why only very few of them would be selected. And with neuroscience: from a huge array of behavioral patterns only some are selected.

Here one can of course try a loophole: Darwinian selection. But there is no selection in the Universe of physicalist. This would require free will and intentionality. The trick does not work.

But what about this network in which biomolecules are connected by this something already mentioned?, asks philosopher. Could this something connect only biomolecules if they are in the same relationship as sender and receiver of radio signal. Could these somethings connect stably only systems possessing common resonance frequencies? Could this criterion could select both the preferred biomolecules and the "reaction vertices" and thus also reaction pathways?

It is easy to guess the reaction of mainstreamer: fairy-taling again.

## 2.4 Where does the coherence come from?

A further mystery is how the biochemical reactions can occur coherently in length scales longer than atomic scale. Without this coherence I could not write this article, play piano, or even raise my hand. If we were just sacks of water containing some chemicals we would be doing science and arts. We would be indeed just sacks of water containing some chemicals in chemical and thermodynamical equilibrium and microscopic sample from this water would characterize us completely.

Mysteriously, the coherence of biodynamics in scales up to the size of the organism emerges somehow. The required coherence need not be quantum coherence - and probably it is not - but it could be induced by quantum coherence. Quantum coherence of what? There is also the problem due to quite too small value of Planck constant. We have learned about the effects supporting the vision about quantum biology. It is now however becoming clear that these effects would however require large value of Planck constant.

Here the philosopher remembers the findings of Blackman and other pioneers of bio-electromagnetism. They found that the irradiation of vertebrate brain by ELF radiation at EEG frequencies scale had effects on both behavior and physiology and these effects look quantal occurring at harmonics of endogenous magnetic field of .2 Gauss.  $E = h \times f$  makes these effects extremely small and totally masked by thermal noise. What if the value of Planck constant were so large that the energies were above thermal energy?

Now the mainstream physicist inside us is getting really angry: is this recklessly speculating philosopher really suggesting that our cherished quantum theory might not be the final word of science?

## 2.5 Morphogenesis

The problem of structure formation in biology - morphogenesis - was put under the rug by most biologists after the emergence of genetics. Sheldrake [4, 5] is one of those who have taken it seriously and has been

labelled as a crackpot by mainstreamers (I have discussed Sheldrake's views from TGD point of view in [4, 23]). One just assumes that the structures are there and performs chemistry around these structures. This approach is very practical and has given an enormous amount of data but very little understanding.

In standard physics the description of spatial structures would be in terms of enhanced densities of biomolecules or of their gradients in some space-time region. This is the only possibility because the space-time of standard physics is topologically and geometrically utterly trivial. Empty Minkowski space is an excellent approximation for it.

What philosopher has to say about this? If space-time topology were topologically non-trivial, situation would change dramatically. Already Wheeler saw this possibility and in the biology inspired by TGD (for which Wheeler suggested its name) all structures correspond to structures of topologically non-trivial space-time identified as surface in certain 8-D space-time: space-time sheets, magnetic flux tubes, etc... The entire TGD inspired quantum biology relies on this vision. The structures that we see around us would represent the non-trivial topology of space-time surface.

All structures - including bio-molecules, membrane like structures, organelles, organs, ... - would be 4-D space-time surfaces. Again philosopher gets excited since this would reduce the notion of shape in biology to a precisely defined and testable geometrodynamics coupling to em fields.

### 2.5.1 The dynamics of space-time surfaces

This dynamics predicts two kinds of space-time regions [21] (see <http://tinyurl.com/yboog5sr>).

1. The regions of first kind are locally minimal surfaces. These minimal surfaces are as 4-D analogs of geodesic lines analogs of asymptotic states of particle physics for which interactions are not on. They also satisfy non-linear geometrization of massless field equations so that both particle and wave aspects are present. What is especially important is that static minimal surfaces have vanishing mean curvature and look like saddles locally. They cannot be closed surface if stationary.
2. Second type of regions are not minimal surfaces: there is a non-trivial coupling of the minimal surface term to 4-force density analogous to the divergence of Maxwellian energy momentum tensor. This is a generalization of the dynamics of a point-like charged particle in Maxwell field. These regions are identified as interaction regions: in particle physics these two regions correspond to external free particles and the interaction region. Magnetic flux tubes play fundamental role in TGD based quantum biology are deformations of string like objects, which represent simplest 4-D minimal surfaces.

Essential is the coupling between induced Kähler form (mathematically like Maxwell field) and the geometry of the surface: the divergence of energy momentum current assignable to the analog of cosmological term (4-volume) equals to the divergence of that assignable to Kähler action: this expresses local conservation of four-momentum. One could also speak about coupling between Kähler field and gravitational field: Penrose's intuition about the the role of gravitation in biology would be correct.

When the coupling is absent, minimal surface property implies the separate vanishing of both divergences and separate conservation of corresponding energy-momenta. All the known extremals of Kähler action are minimal surfaces: this is due to their very simple algebraic properties making easy to discover them. Physically this correspond to quantum criticality: dynamics is universal and does not depend on coupling parameters.

### 2.5.2 General view about morphogenesis

These observations lead to a rather general view about morphogenesis.

1. The presence of the Kähler field (em field is sum of Kähler field and second term) makes possible flow equilibria such as cell membrane, which are not minimal surfaces. These surfaces can be closed and stationary making possible isolation from environment crucial for living organisms.

Spherical soap bubble is a good analogy: it is not minimal surface as the soap films spanned by frames are. They look locally like saddle surfaces with opposite external curvatures in two orthogonal directions, this implies that they cannot be closed surfaces. Bubble is not possible without a pressure difference  $\Delta p$  between the interior and exterior of the bubble: the blowing of the soap bubble generates  $\Delta p$ , and means external energy feed analogous to metabolic energy feed.

$\Delta p$  is analogous to a non-vanishing voltage  $V$  over cell membrane. The electric field of cell membrane and the energy feed providing the energy of electric field as metabolic energy are essential for the stability. More generally,  $V$  would generalize to non-vanishing of energy momentum tensor of Kähler field with non-vanishing divergence serving as a correlate for the energy transfer between Kähler and volume (gravitational) degrees of freedom.

This generalises to all morphologies, which correspond to closed surfaces. They necessarily involve both Kähler electric and magnetic fields coupling to the geometry to stabilize the morphology. This statement would give some content for the exaggerated claim that biology is nothing but electricity + Schrödinger equation that I heard during my first student year.

2. For instance, the presence of Kähler electric field can correspond to electric fields of cell membrane or along a part of body. If it is too weak, things go wrong in development. As was found decades ago, consciousness is lost if the electric field between frontal lobes and hindbrain gets too weak or has wrong direction [8]. Cell dies if the membrane potential becomes zero and EEG disappears in death. Also microtubules have electric field along their axes essential for their existence.

Michael Levin and his collaborators [1, 2, 6] have discovered further fascinating connections between electric fields and morphogenesis. One of the discoveries is that the electric fields of the embryo are controlled by neurons of the still developing brain (see <http://tinyurl.com/y77fcc7r>). This conforms with the view that neurons and their MBs correspond to a higher level in the hierarchy than ordinary cells and there take care of control in longer scales. The MB of the developing brain would be the controller.

3. A non-trivial coupling (four-momentum transfer) between the volume and Kähler degrees of freedom requires that the energy momentum currents have opposite and non-vanishing divergences. For the energy momentum tensor of ordinary Maxwell field the divergence is proportional to the contraction of Maxwell current and Maxwell field so that the current must be non-vanishing.

In TGD the energy momentum tensor is replaced with energy momentum current allowing to have well-defined notion of energy momentum and corresponding conservation laws. Now the divergence contains two terms. The first one is the contraction  $Tr(T_K H^k)$  of energy momentum tensor  $T_K$  of Kähler action with the second fundamental form  $H^k$ : this term proportional to  $T_K$  is new. Second term is proportional to the contraction  $j_K J \nabla h^k$  of the induced Kähler form  $J$  with Kähler current  $j_K$  and gradients  $\nabla h^k$  of imbedding space coordinates analogous the divergence of energy-momentum tensor  $j^\beta F^\alpha_\beta$  in the case of ordinary Maxwell action. One expects both terms to be non-vanishing.

For the mere Kähler action, which I believed for decades to determine the preferred extremals,  $j_K$  is either vanishing or light-like. In presence of coupling it can be both non-vanishing and time-like. The realization that cosmological term is present was forced by the twistor lift of TGD whose existence is possible only for  $H = M^4 \times CP_2$  [14, 18].

4. The predicted stabilizing Kähler (and em) currents would naturally correspond to the DC currents flowing along the body in various scales discovered already by Becker [10, 8] and found to be essential for the survival of the organism. In particular, Becker's DC currents are essential for the healing of

wounds and in the regeneration of organs. In the first first aid stage of the healing DC currents are generated locally and after than central nervous system (CNS) takes care of the generation of the current (for TGD based discussion of Becker currents see [15] (see <http://tinyurl.com/ydg6okkk>) or [11]). Also this is easy to understand from the proposed stability criterion.

This picture is discussed quantitatively in the framework of the twistor lift TGD in [17] [32].

## 2.6 Metabolism

Metabolism is one of the key aspects of biology. We must eat and plants must busily photosynthesize in order to survive. But why metabolic energy feed is needed? Again a mystery.

Non-equilibrium thermodynamics is one attempt to answer this question. Thermodynamical equilibrium is completely uninteresting, entropy is maximal and in the case of local dynamics the state of system is completely determined by a small sample of it. However, if one has energy feed, situation changes since equilibrium becomes flow equilibrium. The energy feed guarantees that there is macroscopic dynamics rather than mere thermal motion at microscopic level.

Also in this case one has essentially the same situation everywhere unless one introduces macroscopic parameters - also energy flow - depending on time and position to get something more interesting. Simple reaction kinematics determined by differential equations can be replaced with that determined by partial differential equations obtained by allowing diffusion. Also temperature, pressure and other thermodynamical parameters can be allowed to depend on position and time. Turing proposed a model for the coloring of Zebra as outcome of this kind of dynamics. The model for neuronal membrane and nerve pulse generation is also a rough model trying to reproduce basic facts about nerve pulse generation using thermodynamics for neuronal membrane regarded as a capacitor. This is of course a mere parametrization of the situation. TGD leads to a quantum model for the situation [12]. Also the interpretation about the role of nerve pulse patterns at neuronal level changes dramatically [24, 30].

In non-equilibrium thermodynamics one speaks of self-organization. One can generalize this notion to quantum self-organization and the crucial criticality associated to the transitions between different self-organization patterns generalizes to quantum criticality [13]. Could these transitions correspond to spatio-temporal self organization patterns, behaviors, functions, programs. This in turn leads to deep connections with conformal symmetry (even its generalization in TGD), fractality, and universality of the dynamics. It is a pity that biologists do not seem to know much about these possibilities.

Now the philosopher starts to talk about ontology. In standard physics the 3-D time= constant snapshot defines the state. This belief has led to weird proposals: in quantized general relativity one ends up with a proposal that there is no time at all.

Could it be that 4-D deterministic time evolution between initial and final states could be more fundamental than the 3-D snapshot? Could superpositions of these 4-D evolutions define quantum states. If so, the state function reductions would occur between these superpositions and their non-determinism would be consistent with the determinism of field equations. Free will would not break laws of physics. It would be like starting new deterministic computer program. Our philosopher calls this ontology Zero Energy Ontology and claims that it leads to a theory of consciousness as a generalization of quantum measurement theory [27] (see <http://tinyurl.com/yctxm2tpd>). Irritating.

## 2.7 Does metabolic energy feed generate conscious information?

The basic question about the role of metabolic energy remains, says the philosopher. What is its real role? Energy feed generates structures and structural complexity means information. It seems that metabolic energy feed involves also a feed of information or generation of information. And because living systems are in question, philosopher cannot avoid the question whether this information is actually conscious information. Is there any other kind of information than conscious information?!

To this question standard physics has no answer: it can only describe entropy mathematically and identification of information as lack of entropy is the easy answer suggested in lack of anything better. The question about a possible measure for conscious information analogous to Shannon entropy is one manner to end up with p-adic physics as a correlate of cognition and the necessary fusion of real and various p-adic physics leads to adelic physics [25, 26]. Adelic physics in turn predicts - surprise- surprise - a hierarchy of phases of matter labelled by the value of Planck constant. These phases residing at these somethings defining the networks - magnetic flux tubes - make possible macroscopic quantum coherence inducing the coherence of living matter.

## 2.8 Genetic code

Genetic code definitely represents information. Is it really an outcome of thermodynamical fluctuation? Is there some deep mathematics associated with the genetic code?, asks the philosopher now.

Genome contains also intronic portion: most of it consists of introns and the intronic portion is the larger the higher the evolutionary level is. The prevailing interpretation has been as "junk". Is it really junk?, wonders philosopher. Luckily, the attitude that trash bin represents the highest level of evolution has begun to slowly change to more rational one.

Could there be a beautiful mathematics behind genetic code? Could it be something similar to codes in computer science and have not only one representation - the chemical one - but numerous representations? If computer science would have developed before genetics - this question would have been completely natural and we would probably know a lot about these representations. Could this dark matter with large Planck constant at these mysterious somethings identified by our philosopher tentatively as magnetic flux tubes realize the really fundamental representation of the genetic code and also of of DNA, RNA, tRNA, and amino-acids in information theoretic sense? And could also radiation provide realization of genetic code necessary for communications? This is what the philosopher claims [22, 29, 28, 19, 34].

## 2.9 Hen-or-egg questions of biology

Standard biology suffers from several hen-or-egg problems as philosopher reminds. Which came first: genes or metabolism? The problem is that genes require metabolism and metabolism requires genes! Genes-first leads to the vision about RNA world and metabolism-first to lipids world idea.

The emergence of basic biomolecules is the second problem. What selected these relatively few basic molecules from huge multitude of molecules? Again hen-or-egg problems emerge. Which came first: proteins or the translation machinery producing them from RNA? Did RNA arrive before proteins or did proteins and RNAs necessary for their transcription and translation machinery emerge first. One can argue that ribozymes served as catalysts for RNA replication but how RNAs managed to emerge without replication machinery involving ribozymes? What about DNA: did it emerge before RNA or could it have emerged from RNA? It seems that something extremely important is missing from the picture.

TGD predicts the existence of dark variants of basic biomolecules DNA, RNA, tRNA, and amino-acids (AAs). One can ask whether something very simple could be imagined by utilizing the potential provided by dark variants of bio-molecules present already from beginning and providing both genes and metabolism simultaneously.

One can start from a couple of observations which forced myself to clarify myself some aspects of TGD view and also to develop an alternative vision about prebiotic period.

1. Viruses are probable predecessors of cellular life. So called positive sense single stranded RNA (ssRNA) associated with viruses can form temporarily double strands and in this state replicate just like DNA (see <http://tinyurl.com/yc5f8b3t>). The resulting single stranded RNA can in turn be translated to proteins by using ribosomal machinery. RNA replication takes place in so called



viral replication complexes associated with internal cell membranes, and is catalyzed by proteins produced by both virus and host cell.

Could ribozyme molecules have catalyzed RNA replication during RNA era? For this option AA translation would have emerged later and the storage of genetic information to DNA only after that. There is however the question about the emergence of AAs and of course, DNA and RNA. Which selected just them from enormous variety of options.

2. Lipid membranes are formed by self-organization process from lipids and emerge spontaneously without the help of genetic machinery. It would be surprising if prebiotic life would not have utilized this possibility. This idea leads to the notion of lipid life as a predecessor of RNA life. In this scenario metabolism would have preceded genes (see <http://tinyurl.com/y7ehv8cq> and <http://tinyurl.com/y8n1tb9e>). The basic objection against both genes-first and metabolism-first options is that they need each other!

Consider now the situation in TGD.

1. In TGD framework the dark variants of DNA, RNA, AA, and tRNA would provide the analogs of genes and all basic biomolecules. They would also provide a mechanism of metabolism in which energy feed by (say) solar radiation creates so called exclusion zones (EZs) of Pollack [7] in water bounded by a hydrophilic substance. EZs are negatively charged regions of water giving rise to a potential gradient (analog of battery) storing chemically the energy provided by sunlight and the formation of these regions gives rise to dark nuclei at magnetic flux tubes with scaled down binding energy.

When the p-adic length scale of these dark nuclei is liberated binding energy is liberated as metabolic energy so that metabolic energy feed giving basically rise to states with non-standard value  $h_{eff}/h = n$  of Planck constant is possible. For instance, processes like protein folding and muscle contraction could correspond to this kind of reduction of  $h_{eff}$  liberating energy and also a transformation of dark protons to ordinary protons and disappearance of EZs.

The cell interiors are negatively charged and this is presumably true for the interiors of lipid membranes in general and they would therefore correspond to EZs with part of protons at magnetic flux tubes as dark nuclei representing dark variants of basic biomolecules. Already this could have made possible metabolism, the chemical storage of metabolic energy to a potential gradient over the lipid membrane, and also the storing of the genetic information to dark variants of biomolecules at the magnetic flux tubes formed in Pollack effect.

2. In TGD framework biochemistry would have gradually learned to mimic dark variants of basic processes as a kind of shadow dynamics. Lipid membranes could have formed spontaneously in water already during prebiotic phase when only dark variants of DNA, RNA, AAs and tRNA, water, and lipids and some simple bio-molecules could have been present. The dark variants of replication, transcription and translation would have been present from the beginning and would still provide the templates for these processes at the level of biochemistry.

Dark-dark pairing would rely on resonant frequency pairing by dark photons and dark-ordinary pairing to resonant energy pairing involving transformation of dark photon to ordinary photon. The direct pairing of basic biomolecules with their dark variants by resonance mechanism could have led to their selection explaining the puzzle of why so few biomolecules survived.

This is in contrast with the usual view in which the emergence of proteins would have required the emergence of translation machinery in turn requiring enzymes as catalyzers so that one ends up with hen-or-egg question: which came first, the translation machinery or proteins. In RNA life option similar problem emerges since RNA replication must be catalyzed by ribozymes.

3. Gradually DNA, RNA, tRNA, and AA would have emerged by pairing with their dark variants by resonance mechanism. The presence of lipid membranes could have been crucial in catalyzing this pairing. Later ribozymes could have catalyzed RNA replication by the above mentioned mechanism during RNA era: note however that the process could be only a shadow of much simpler replication for dark DNA. One can even imagine membrane RNAs as analogs of membrane proteins serving as receptors giving rise to ionic channels. Note however that in TGD framework membrane proteins could have emerged very early via their pairing with dark AA associated with the membrane. These membrane proteins and their RNA counterparts could have evolved into transcription and translation machineries.

DNA molecules would have emerged through pairing with dark DNA molecules. The difference between deoxy-ribose and ribose would correspond to the difference between dark RNA and dark DNA manifesting as different cyclotron frequencies and energies making possible the resonant pairing for frequencies and energies. Proteins would have emerged as those proteins able to pair resonantly with dark variants of amino-acid sequences without any pre-existing translational machinery. It is difficult to say in which order the basic biomolecules would have emerged. They could have emerged even simultaneously by resonant pairing with their dark variants.

## 2.10 How life began?

The central question of biology is "How life began?" and philosopher certainly agrees with this. The dark variants of biomolecules suggest not only a solution to various paradoxes but also a concrete answer to this question.

The transcription machinery for rRNA including ribozymes and mRNA coding for the proteins associated with ribosomes is central for the translation. The DNA coding for rRNA is associated with nucleolus (see <http://tinyurl.com/yavahwzt>) in the center of the nucleus.

1. After the emergence of the first ribosome the ribosomes of the already existing nucleus can take care of the translation of the ribosomal proteins. But how could the first ribosome emerge? This question leads to a paradox bringing in mind self-reference - the basic theme of Gödel-Escher-Bach of Douglas Hofstadter, perhaps the most fascinating and inspiring book I have ever read. The ribosomal proteins associated with the first ribosomes should have been translated using ribosome, which did not yet exist!
2. Could the translation of the first ribosomal proteins directly from the dark variants of these proteins solve the paradox? The idea of shadow dynamics induced by the pairing of basic biomolecules with their dark variants even allows to ask whether the replication, transcription, and translation could occur at dark level so that dark genes for ribosomes would be transcribed to dark ribosomal RNA and dark mRNA translated to dark AA associated with the ribosomes. These in turn would pair with ordinary ribosomal RNA and AA.
3. But what about dark variants of ribosomes? One can encounter the same paradox with them if they are needed for the translation. Could it be that dark variants of the ribosomes are not needed at all for the translation but would only give rise to ordinary ribosomes by the pairings basic biomolecules and their dark variants. Dark DNA would pair with dark mRNA, which pairs spontaneously with dark tRNA. Once the ordinary ribosomes are generated from the dark ribosomes by pairing, they could make the translation much faster.
4. There is however a problem. Both dark RNA and AA correspond to dark nuclear strings. Dark tRNA realized as nuclear string in the proposed manner does not have a decomposition to dark AA and dark RNA as ordinary tRNA has. The pairing of dark tRNA and dark mRNA should rise to dark AA and dark nuclear string - call it  $X$  - serving as the analog for the pairing of mRNA sequence with "RNAs" of tRNAs in the ordinary translation.

5. How to identify  $X$ ? Could the translation be analogous to a reaction vertex in which dark mRNA and dark tRNA meet and give rise to dark AA and  $X$ ?  $X$  cannot be completely trivial. Could  $X$  correspond to the dark DNA?! If so, the process would transcribe from dark DNA dark RNA and translate from dark RNA and dark tRNA AA and dark DNA. This would lead to an exponential growth of dark DNA and other dark variants of bio-molecules. This exponential growth would induce exponential growth of the basic bio-molecules by pairing. Life would have emerged! No RNA era or lipid era might be needed. All basic biomolecules or their precursors could emerge even simultaneously - presumably in presence of lipids - but this is not the only possibility.

One can take a more precise look at the situation and try to understand the emergence of bio-molecules and their basic reactions as shadows of the dark variants of bio-molecules appearing in dark particle reactions. The basic idea is that same dark reaction can give rise to several reactions of biomolecules if varying number of the external dark particles are paired with corresponding bio-molecules. Under what conditions this pairing could occur, is left an open question. Consider now the dark  $2 \rightarrow 2$  reactions and possible reactions obtained by pairing of some particles.

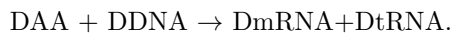
1. The reaction



gives rise to translation  $\text{mRNA} + \text{tRNA} \rightarrow \text{AA}$  if DDNA-DNA pairing does not occur in the final state but other dark particles are paired with the their ordinary variants. If only DmRNA-mRNA and DDNA-DNA pairings occur, the reaction gives the reversal  $\text{mRNA} \rightarrow \text{DNA}$  of transcription.

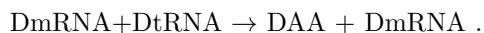
It should be easy to check whether this is allowed by the tensor product decomposition for the group representations associated with dark proton triplets [22]. Same applies to other reactions considered below.

If this reaction is possible then also the reversal



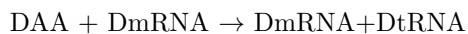
can occur. If only DDNA-DNA and DmRNA-mRNA pairings occur this gives rise to transcription of  $\text{DNA} \rightarrow \text{mRNA}$ . Also reverse translation  $\text{AA} \rightarrow \text{mRNA}$  is possible.

2. One can consider also the reaction



If all pairings except DAA-AA pairing are present, the outcome is instead of translation the replication of mRNA such that the amino-acid in tRNA serves the role of catalyzer. I have considered the possibility that this process preceded the ordinary translation: in a phase transition increasing  $h_{eff}$  the roles of AA and RNA in tRNA would have changed [34].

If this reaction is possible then also its reversal



is allowed. If all pairing except DmRNA-mRNA occur, this gives rise to  $\text{AA} + \text{RNA} \rightarrow \text{tRNA}$  allowing to generate tRNA from AA and RNA (not quite RNA).

3. The replication of DNA strand would correspond at dark level to a formation of bound states by the reaction



in which all particles are paired. The opening of DNA double strand would correspond to the reverse of this bound state formation.

These dark particle reactions behind the shadow dynamics of life should be describable by S-matrices, which one might call the S-matrix of life.

1. For instance for



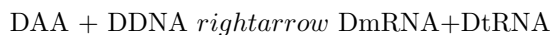
where  $X$  can be  $\text{DmRNA} + \text{DtRNA}$  (nothing happens - forward scattering) or  $\text{DAA} + \text{DDNA}$  and perhaps even  $\text{DAA} + \text{DmRNA}$ , one would have unitary  $S$ -matrix satisfying  $SS^{\text{dagger}} = Id$  giving probability conservation as  $\sum_n p_{m,n} = |S_{mn}|^2 = 1$  as a special case. Writing  $S = 1 + iT$  unitarity gives  $i(T - T^\dagger) + TT^{\text{dagger}} = 0$  giving additional constraints besides probability conservation.

For



the non-vanishing elements of  $T$  are only between pairs  $[(\text{DmRNA}, \text{DtRNA}), (\text{DAA}, \text{DDNA})]$  for which mRNA pairs with tRNA and DNA codes for AA. Unitary matrix would be coded by amplitudes  $t(\text{AA}, \text{DNA}_i(A))$  satisfying  $\sum_i p_i(\text{DAA}) = p(\text{DDNA} + \text{DAA})$ ,  $p_i(\text{AA}) = |t(\text{DAA}, \text{DDNA}_i(A))|^2$ .  $p(\text{DDNA} + \text{DAA})$  equals to  $p(\text{DDNA} + \text{DAA}) = (1 - p)Br(\text{DDNA} + \text{DAA})$ , where  $p$  is the probability that nothing happens (forward scattering) and  $Br(\text{DDNA} + \text{DAA})$  is the branching ratio to  $\text{DDNA} + \text{DAA}$  channel smaller than 1 if  $Br(\text{DDNA} + \text{DmRNA})$  is non-vanishing. The natural interpretation for  $p_i(\text{AA})$  would be as probability that  $\text{DNA}_i$  codes for it.

2. For the reverse reaction



it is natural to assume that  $\text{DtRNA}$  corresponds to any tRNA, which pairs with RNA. The AA associated with this tRNA is always the same but the counterpart of RNA can vary (wobbling). One can speak of the decomposition of dark genetic code to  $\text{DmRNA} \rightarrow \text{DtRNA} \rightarrow \text{DAA}$  to a pair of codes mapping  $\text{DmRNA}$  to  $\text{DtRNA}$  and  $\text{DtRNA}$  to  $\text{DAA}$  [31]. There is a set  $\text{tRNA}_i(\text{mRNA})$  of tRNAs coding for given mRNA, and the probabilities  $p_i(\text{DmRNA})$  sum up to  $p = \sum_i p_i(\text{DmRNA}) = (1 - p)Br(\text{DmRNA} + \text{DtRNA})$ , where  $p$  is the probability for forward scattering and  $Br(\text{DmRNA} + \text{DtRNA})$  is the branching fraction. The natural identification of  $p_i(\text{DmRNA})$  is as the probability that mRNA pairs with  $\text{tRNA}_i$ .

A possible weak point of the proposal is pairing: what are the conditions under which it occurs and are different pairing patterns possible. Possible second weak point is purely group theoretic: one should check whether which reactions are allowed by the tensor product decompositions for the states of dark proton triplets.

## 2.11 The mystery of replication

Replication is one of the deepest mysteries of biology. It is really something totally counterintuitive if cell is seen as a sack of water plus some chemicals. We have a lot facts about what happens in the replication at DNA level but how this miracle happens is a mystery. At cell level the situation gets even more complex.

Philosopher thinks that behind the chemistry there might lurk a much simpler quantum dynamics and that chemistry only makes its best to mimic this deeper dynamics. Is biochemistry controlled by something? Does this something provide a template for the dynamics at chemical level? The idea about the presence of this something popped up already in the mystery of EEG. What could this something perhaps receiving sensory information from vertebrate brain and maybe providing feedback as control signals affecting also chemistry?

Now our brave philosopher attacks the length scale reductionism again. Isn't it quite too much to require that all these replications in different length scales would result as accidental "emergence" due to thermodynamical fluctuations? Could the dynamics be fractal with essentially same patterns - for instance replication - occurring in different scales. Could this dynamics be induced by what happens on this something.

Philosopher also suggests a concrete model for the controlling level: dark matter with large value of Planck constant  $h_{eff}/h_0 = n$  at magnetic flux tubes and asks whether the conjectured dark realization of DNA in various scales performs the fundamental replication inducing in turn the biological replication in various scales as a mimicry? This would simplify the situation enormously but in totally different manner than length scale reductionism. Morphogenesis controlled by the hierarchy of dark realizations of genetic code would be the basic vision (see <http://tinyurl.com/yalny39x>). This would simplify the situation enormously but in totally different manner than length scale reductionism.

TGD suggests also a purely topological element involved with replication. Magnetic body (MB) could replicate [15]. Replication would be like 3-vertex of Feynman diagram representing the decay of a particle to two particles. MB or part of it regarded as particle like entity splits into two. The incoming 4-surface and two outgoing 4-surfaces meet along 3-D surface common to all three. After that various molecules would self-organize around the resulting templates. This could happen also for the MB of dark DNA in replication and induce the bio-chemical part of replication.

## 2.12 Homeostasis

Homeostasis means that system is able to preserve its flow equilibrium under changing conditions. This involves many-layered hierarchies of pairs of control signals with opposite effects so that the system stays in equilibrium. For instance, we could not stand without this control system as one can easily check by using non-living test body! For instance, in bio-chemical homeostasis the ratios of concentrations remain constant. For the philosopher it is not at all obvious whether ordinary chemistry can explain homeostasis.

In zero energy ontology (ZEO) one can imagine very fundamental mechanism of homeostasis.

1. Zero energy states are pairs of ordinary 3-D states with members located at opposite boundaries of causal diamond (CD). Their total quantum numbers are opposite, which is only a manner to say that conservation laws hold true. The space-time surfaces connecting the 3-surfaces are preferred extremals of the action principle.

In quantum field theory this picture can be seen only as a book keeping trick and one assumes that space-time continues beyond causal diamond. There is however no need for this in TGD framework although it is natural to assume that there is some largest CD beyond which space-time surfaces do not continue. CDs form a hierarchy and sub-CDs of this CD can be connected by minimal surfaces, which are analogs of external particles. One obtains networks analogs to twistor Grassmannian diagrams.

2. Conscious entities (selves) correspond in ZEO to a sequences of state function reductions having interpretation as weak measurements, "small" state function reductions [27]. In given weak measurement the members of the zero energy state at the passive boundary of CD are not affected: this is essentially Zeno effect associated with repeated measurements in ordinary quantum theory. The members of the state pairs at the active boundary of CD change and also the temporal distance between the tips of CD increases: this assigns a clock time to the experienced flow of time as sequence of state function reductions.

Eventually it becomes impossible to find observables, whose measurement would leave the passive parts of the zero energy state invariant. First "big" state function reduction changing the roles of active and passive boundaries of CD takes place and time begins to run in opposite direction since the formerly passive boundary recedes away from the formerly active boundary which is now stationary. Self dies and re-incarnates with an opposite arrow of time. In TGD biology these two time-reversed selves are proposed to correspond to motor actions and sensory perceptions.

Already Fantappie [9] realized that two arrows of time seem to be present in living matter (consider only spontaneous assembly of bio-molecules as decay in opposite direction) and introduced the notion of syntropy as time-reversed entropy. For an observer with given arrow of time, a system

with opposite arrow of time seems to break the second law. Temperature and concentrations gradients develop, system self-organizes.

3. These two quantal time evolutions with opposite arrows of time look very much like competing control signals in homeostasis. The 4-D conscious entities corresponding to control signals would have finite lifetime so that in their ensemble the effects of the signals with opposite arrows of time tend to compensate. This would give rise to homeostasis.

## 2.13 Evolution

Philosopher cannot avoid the question "What is evolution?" In standard biology evolution is mystery. If one believes on standard thermodynamics, evolution is impossible by second law and the eventual heat death is unavoidable. Evolution means generation of structures and second law indeed states that all gradients die so that the final state is totally uninteresting homogenous stuff.

The weird proposal that biology is just an enormous thermodynamical fluctuation has been already mentioned. Boltzmann brain was indeed a kind of fad of pop physicists for some years ago. The idea - if you want to call it such - was that Boltzmann brains - and also ours - popped up from the multiverse by a complete accident. One could even argue that this occurred only at planet Earth to make the claim more plausible. To my opinion this is however not science anymore.

Philosopher asks questions and now the most obvious questions are following. Is evolution something much more general than biological evolution? Is evolution a basic aspect of physics as already cosmological evolution suggests? Is evolution "must", something completely unavoidable? What could force it?

The Universe governed by second law certainly does not allow evolution: just the contrary. Could the increase of entropy and increase of conscious information and development of cognition relate somehow? It has been argued by Jeremy England [3] (see <http://tinyurl.com/o64rd7o>) that biological evolution involves increase of the rate of entropy production as any-one can see by just looking around. These two things are not the same but are they somehow related [20] (see <http://tinyurl.com/zjp3bp6>).

Philosopher already mentioned that p-adic physics as physics of cognition not only leads to a measure for conscious information - something very non-trivial - but to adelic physics fusing physics in various number fields [25, 26]. Adeles form a hierarchy labelled by the dimension of the extension of rationals inducing the extension of p-adic number fields labelled by primes. This dimension corresponds to the effective value of Planck constant and the larger it is, the larger the scale of quantum coherence is.

This has been already said but now comes the basic point. Since the number of extensions of rationals with dimension larger than given integer  $n$  is finite and the number of those with dimension larger than  $n$  is infinite, this dimension is bound to increase in statistical sense in the sequence of state function reductions recreating the quantum Universe again and again. Evolution is unavoidable! This is like random work from origin upwards. The height from the origin unavoidably increases.

Even more, the total negentropy coming from various p-adic sectors turns out to be larger than the entropy coming from the real sector. The bad news - not actually a news - is that increase of this negentropy is accompanied by the increase of entropy: civilizations indeed have the bad habit of polluting their environments. The good news is that negentropy increases faster than entropy: for a trivial extension of rationals from which everything would have started, negentropy equals to entropy. But for more complex extensions it is larger.

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